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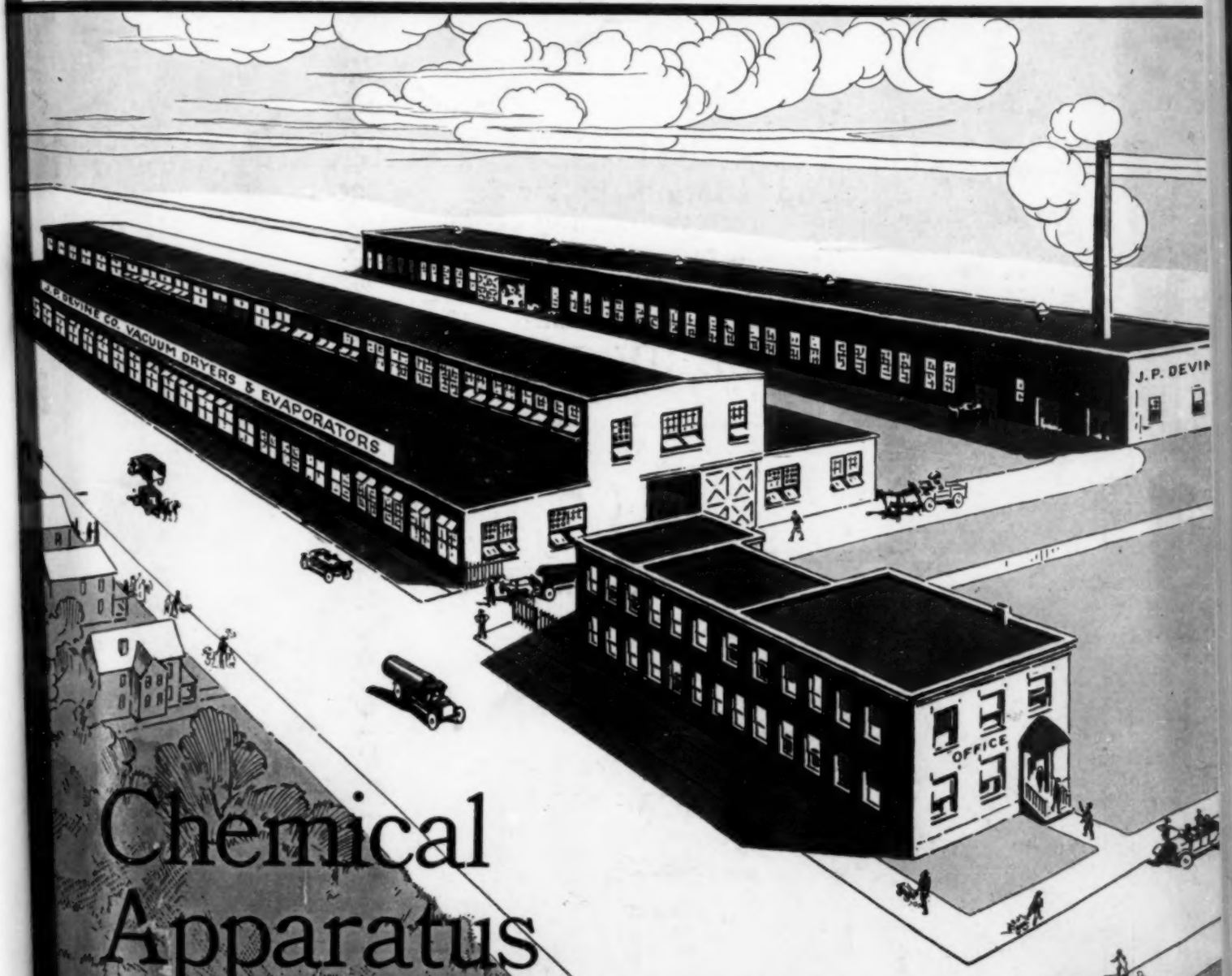

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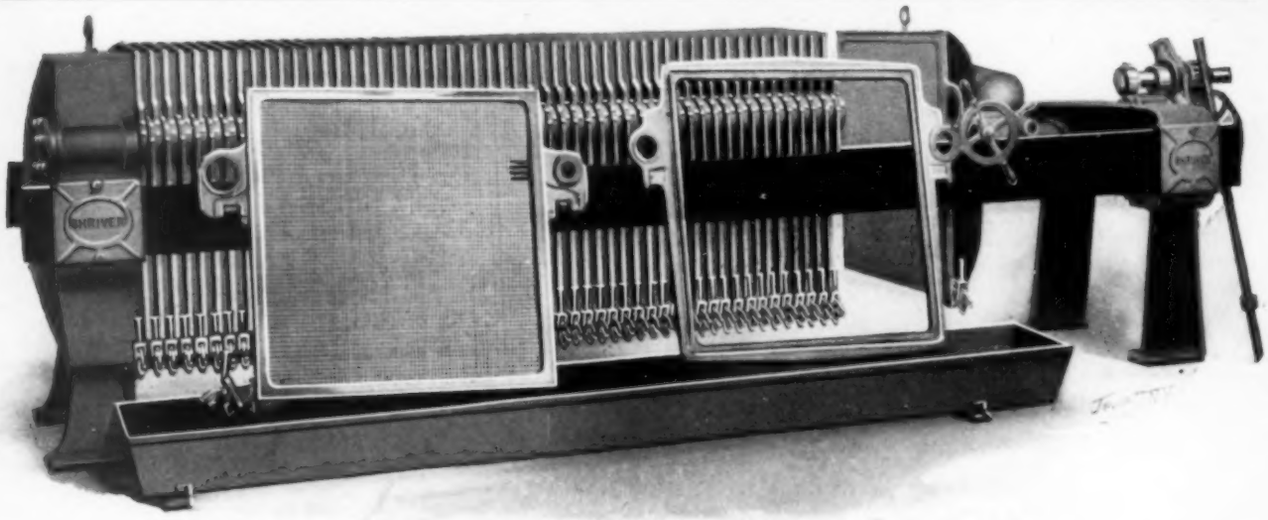

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California and the International Engineering Congress

Next week, from Sept. 20 to 25, the International Engineering Congress, to which sunkissed California has invited the engineers of the world, will meet in San Francisco. That it will be a great success is assured by the simple fact that San Francisco is the hostess and the national societies of civil, electrical, mechanical, and mining engineers stand sponsor. But it is a melancholy reflection to think that this is the only survivor of so many congresses planned.

The year 1915 was intended to be one of promotion of international good will and friendship by international congresses. It was not so to be. There has been no International Congress of Applied Chemistry in St. Petersburg or Petrograd, no International Congress of Mining, Metallurgy, Engineering and Economic Geology in London. Even the International Electrical Congress which had been planned for San Francisco was called off, and this is characteristic. The Electrical Congress was managed in the East and was called off; the Engineering Congress was managed from San Francisco, and its managers with true Californian spirit stuck to their purpose and carried it through and will achieve the success which their courage deserves.

That in number of members and in international character the International Engineering Congress will seriously suffer from the European war goes without saying. That it can nevertheless be made a real success San Francisco will prove. It is true that the conditions resulting from the European war even in neutral countries have greatly reduced the anticipated enrollment of members, but they have not resulted in a proportionate reduction in either the quality or the quantity of the papers offered for publication in the Transactions. And the Transactions are, after all, the final test of the success of the Congress. But that the Congress and its Transactions should be of the greatest possible benefit to the engineering professions, it is essential that it should enroll the greatest possible number of members.

It is not yet too late to join the Congress. The address of the International Engineering Congress is Foxcroft Building, San Francisco, and the membership fee is five dollars, which entitles the member to full participation in the Congress, a volume reporting the general proceedings, and any single volume of the Transactions which the member may select out of the set of ten volumes. These ten volumes relate to (1) Panama Canal; (2) Waterways and Irrigation; (3) Municipal Engineering; (4) Railways and Railway En-

gineering; (5) Materials of Engineering Construction; (6) Mechanical Engineering; (7) Electrical and Mechanical Engineering; (8) Mining and Metallurgy; (9) Naval Architecture and Marine Engineering; (10) Military Engineering. It may finally be mentioned that for the section of metallurgy five symposia have been arranged on iron and steel, copper, gold and silver, zinc, and the utilization of fuels in metallurgy, the editors being Henry M. Howe, E. P. Mathewson, C. W. Merrill, W. R. Ingalls and C. H. Fulton respectively.

So much may be said as to what may be expected in return for the membership fee. But to look at the Congress in this way shows a rather narrow viewpoint, as the idealistic side of the whole undertaking is entirely lost sight of. The Congress was organized to commemorate and celebrate one of the greatest peaceful engineering achievements of recent times—the completion of the Panama Canal. In these frightfully distressing war times, the Engineering Congress will emphasize the triumph of the peaceful work of the engineer. To enroll as a member means to avow the truth of this idea and is but a small tribute to the Californians who have made the congress a reality.

* * *

Yet the courageous manner in which the International Engineering Congress has been organized is but one single expression of the general spirit that moves the whole Californian people. They mind their own business and in that trait alone they are almost without competitors, and that is one reason why Californians can do things that seem impossible elsewhere. And they mind their own business with the full-blooded enthusiasm and never-dying optimism which they inherited from their pioneer ancestors. With the simple faith in the righteousness of their doings, they perform miracles. After the fire of 1906 how could they have built up otherwise in a few years a new and more beautiful San Francisco? How could they have organized otherwise nine years later a World's Fair and make a success of it—a big success, aesthetic, industrial, cultural, and even financial? In these distressing days when the rest of the world is in flames or is shaking, San Francisco stands firm and strong and happy—an inspiration to all who go and see and wonder.

It is a pity that the East in its troubles does not seem able to derive from the West that inspiration which it needs and could get abundantly. At least if it is true that the newspapers give the people what the people want, it is distressing to see in Eastern newspapers nothing but glaring headlines on the European war. Has anyone seen in any New York newspaper a headline on the wonderful success which San Francisco is making, even beyond her own expectations? Must we always look backward toward Europe? Have the people of the East lost the spirit of those pioneers who followed the course of the sun and conquered the West? Can't we learn to look westward and forward toward the Golden Gate and the great empire at the Pacific Coast? Never has been the name of the *Pacific* Coast as true as to-day.

Of course, the one encouraging feature in this situation is obvious; it is that the situation has produced automatically its own remedy. What no argument about the wisdom or decency of Americans seeing America first could have done, has been practically forced upon American travelers by the European war and by the San Francisco and San Diego Expositions. And every Eastern traveler comes back to the East as an enthusiastic voluntary advertising agent of the greatness of the Pacific Coast.

This is a big gain for the East, but it is not the main point for the West. What are as much important for the West as the very large number of average sight-seeing travelers, are the visits of technical and engineering societies. This week, from September 16 to 18, San Francisco has the meetings of the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, the Society of Naval Architects and Marine Engineers, and the American Electrochemical Society, previous to the International Engineering Congress next week. Many other societies have met and will meet on the Coast. Of the trip of the American Institute of Chemical Engineers from San Diego to San Francisco and Seattle and of the trip of the American Chemical Society in counter current from Seattle to San Francisco we give quite a full account in this issue. But the interesting point in this connection is this: What has the Pacific Coast for the chemist and what has the chemist for the Pacific Coast?

The mining engineer blazed the trail and the metallurgist followed, and the more the mineral resources of the Pacific Coast will be utilized the more will the chemical training be needed in the metallurgist. This is obvious. The Bully Hill mine is a famous case in point. But outside of metallurgy the chemist's work in California is restricted at present chiefly to oil and gas and to sugar. These are big fields, very big fields. But they seem small compared with the unlimited possibilities not yet touched.

One single example may explain what we mean. A few years ago, a strong-hearted man was shown the immense kieselguhr deposits at Lompoc in Santa Barbara County and the prospects of oil wells were pointed out to him. This did not appeal to him, as any other rich man could have tackled that proposition. What appealed to him was the creation of a new American industry—that of kieselguhr; he had become a true Californian on California soil. The mining problem was simple enough, but the chemical problem of utilization for heat insulation, sugar filtration, oil refining, and we don't know what else, was everything.

There are unnumbered opportunities of this kind for the chemist in the development of the natural resources of the Pacific Coast. Mr. Baruch's paper on the Southwest, like Dr. Benson's paper on the Northwest, will prove suggestive. If the first semimonthly edition of this journal has become almost completely a Pacific Coast issue, let us hope that this is a happy omen on the future interrelation between chemistry and the Pacific Coast.

A Bit of Economic Mineralogy

If you see it in *The Sun*, it's so. We cull the following contribution to economic mineralogy from *The Sun* of Aug. 20:

> One of the effects of the war upon this country has been to develop resources of which we before had no knowledge. This has been shown in the development of dye, potash and certain mineral industries. Now it has been discovered that there are immense deposits of silica in the sand hills of western Kansas, and so great has grown the demand for the substance since the supply from Germany has been cut off that several large plants have been built for treating and marketing it. We have thus been able not only largely to supply our own demand, but to transform what was once considered waste land into productiveness.

The still more important discovery that the coal deposits of Pennsylvania contain large quantities of carbon has rendered that state, at least, independent of imported fuels; and since the scientific application of the oxometer has demonstrated the presence of not inconsiderable quantities of oxygen in the atmosphere of the western hemisphere it is anticipated that before very long respiration may be possible in this country without the use of European oxygen.

The Iron Trade's Divergences Under War Demand

It may be interesting to recount some of the divergences, amounting occasionally to definite dislocations, produced in the iron trade by the demand for war material. As is doubtless quite well recognized, nearly all if not quite all the increased demand for steel, as compared with that of last year, is due to the war. The measure of the demand upon the steel mills is not merely the quantity of war material they are producing, for ordinary domestic buyers, jobbers and manufacturing consumers have been moved to purchase ahead, and to increase their stocks, because the magnitude of the war demand made them fear they would not find themselves with all the material needed unless they were forehanded in their purchases.

An outstanding divergence is the fact that the steel works are producing pig iron at a rate fully 5 per cent in excess of their best previous rate, reached early in 1913, while the merchant furnaces are producing 20 per cent less than at that time. The demand has run to steel, not to iron castings. The iron cannon ball is far in the past.

The demand for steel has run very strongly to open-hearth, but open-hearth steel has become so scarce that many consumers who ordinarily use open-hearth have been induced to take Bessemer. Very likely they are finding it more suited to their purpose than they expected.

For the first time in their history a large use has been found for the rail mills, apart from the rolling of rails. Of course there have been interchangeable mills, rolling billets or rails at will, but few such have been built in recent years. Now a very large tonnage of rounds, over 3 in. in diameter, is being rolled on rail mills, the section being approximately the same weight as that of standard rails. At least half a dozen rail mills are so engaged. The railroads, which have had no occasion since 1907 to worry about securing any delivery desired upon rails, are now seriously concerned over the prospect, and are beginning to buy rails for 1916 delivery.

The rise in the price of spelter, due to the combined influence of England's supplies from Germany and Belgium, equal to 15 or 20 per cent of the world's normal requirements, being shut off, and the large consumption in the manufacture of war material, has almost killed the galvanized sheet industry. About one-eighth the weight of the average gage galvanized sheet is spelter, while over a period of years spelter sold per pound at about three times the price of the uncoated steel sheet. In recent months spelter has been fluctuating between three and five times its former cost. When spelter has advanced the mills were afraid to sell galvanized sheets; when it declined the buyers were afraid to buy and the current production of galvanized sheets is only about one-third normal.

Various price relations in finished steel products have been disturbed. For many years steel plates brought from $1 to $2 a ton more than steel bars, but in the past few months the divergence has been as much in the other direction.

During the first six months of this year finished steel prices rose steadily, by an average not far from $3 a ton, while pig iron fluctuated within narrow limits and showed no general advance. The pig-iron market was largely a function of foundry activity, which was light. Since July 1 there have been sharp advances in pig iron prices. These advances, while harmonizing with the rise in steel prices, have occurred with a much smaller turnover in the pig-iron market than ever before occurred during a similar rise in price, and the advance may perhaps be attributed more to sentiment than to an operation of the law of supply and demand.

The large steel rounds being rolled in tens of thousands of tons a week involve unprecedentedly heavy cropping, the extreme being 35 per cent from the top and 5 per cent from the bottom. Incidentally this cropping is usually required to be done from the ingot and by sawing, which has necessitated some rearrangements in equipment. What to do with the crops is furnishing a more important problem. The markets have probably not yet felt all the influences which this large production of crops is likely to exert. Scrap, pig iron and billets may within a few months be found in new relations with each other. The measure of production is the capacity of the open-hearth furnace, and if all the crops are charged into the furnace, together with other scrap produced by the mill, the supply of scrap otherwise drawn from the mill is not required, and even the consumption of pig iron may be curtailed. Open-hearth steel billets are now very scarce, but if the crops should find their way largely into billets this situation might be very markedly altered. The situation merely presents possibilities. The specifications vary greatly with different orders and the various mills that have accepted the orders may work out their problems in very different ways.

Readers' Views and Comments

The Potash Situation

To the Editor of Metallurgical & Chemical Engineering:

Sir: Mr. Dolbear, in his instructive article on the potash situation in your August number, apparently overlooks altogether the only potash resource in the United States that at present promises to produce potash to any extent at an early date.

The Searles Lake project in Southern California is unfortunately slow in its development, and the other prospective potash sources mentioned are none of them being worked on a scale much beyond the experimental, if they are worked at all.

The potash source which Mr. Dolbear has overlooked is the alunite deposits in Utah. These promise to deliver at an early date a marketable soluble potash salt.

Alunite, being an insoluble hydrous potassium sulphate, can readily be dehydrated and partly decomposed by calcination. In doing this the water is driven off and the aluminum sulphate is decomposed, leaving insoluble aluminum oxide and the soluble potassium sulphate.

Active development work is going on in the alunite deposits in Utah. New veins are being found, and one mill is under construction, and still a couple of others are projected, and the construction of these is expected to start at an early date.

The mill in which the ore is to be calcined, now under construction, is owned by the Minerals Products Company of New York City, and it is generally understood that the products from the mill will be disposed of by the Armour Company.

One hundred tons of alunite per day the plant is planned to take care of, and this amount of alunite will, on calcination, produce twenty tons of potassium sulphate, and thirty-seven tons aluminum oxide.

Considering the total consumption of potash per year in the United States for fertilizer purposes, it is apparent that twenty tons per day is only a very small fraction of the total fertilizer needs of the country, but, at the same time it certainly indicates a good start, and the existence of a domestic source of potash readily made available.

The aluminum oxide obtained in the calcining of the alunite is a by-product, and contains about 99 per cent of Al_2O_3, and approximately 1 per cent of impurities, such as silica and other metallic oxides.

This aluminum oxide can with slight expense and with some care be further purified, and in such condition it may be used in the manufacture of metallic aluminum.

The output of aluminum oxide from even a moderately sized potassium sulphate plant would be considerable, and if all the oxide of this first installation were reduced into metal, some eighteen tons of aluminum would be produced daily, or close to one-fifth of the total aluminum production in the United States per day during 1913.

The thought has been launched that by obtaining this aluminum oxide as a by-product at practically no cost it would be feasible to manufacture aluminum so cheaply that it could be sold at such a low price that the usages for aluminum would be very materially broadened.

The potash situation could well be considered alarming at present in the United States, with the German supply altogether eliminated, but fortunately there are stored enormous quantities of potash all through the country.

It is unfortunate that the chemical combination in which the potash occurs is, with the exception of alunite, such that it involves considerable amount of expense and labor to obtain it in a soluble condition.

There are many processes evolved for the purpose of making these potash resources available, but so far none has been successful enough to justify its operating on a scale much beyond the experimental stage.

This does not eliminate the possibilities that all the potash stored in the Lencite Hills in Wyoming and in the feldspathic rock deposits all through the country cannot be made available at an early date, but it is "up to the chemists" of the country to economically sever the pernicious hold silica has on the much needed and coveted potash.

It has struck me that the chemical profession could in no better way serve our country to-day than assist in solving the potash situation, expedite the liberation of the fettered potash which in reality represents our nation's daily bread, and possibly in years to come the daily bread of many of our European neighbors.

To accomplish the expeditious solving of this problem, I ask you whether a joint committee could not be formed among the leading chemists of the United States, immaterial if they belong to any chemical societies or not, for the purpose of discussing this matter and evolving methods by which to accomplish this. The co-operation of the people and the Government of the United States could certainly be counted upon, financially as well as otherwise.

Any valuable inventions made and processes developed by this committee should be patented, but these patents would all be turned over to the United States Government, making the use of patents and processes free to everybody.

The successful solving of this problem at this time, under these conditions, would build a monument to the chemical profession which time could never obliterate.

J. W. BECKMAN.

San Francisco, Cal.

Repairing Furnace Linings with Compressed-Air Gun and Torch

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In your issue for April, 1915, page 250, I note reference to my patented process for forming and repairing furnace linings by means of a compressed-air gun combined with a torch, the object being to form a dense vitrified lining. As I am not financially interested in this patent in any way my opinion on the process may be considered unbiased. The idea of using a compressed-air gun to project materials into a furnace is not new; but from my experience with processes I have come to realize that there is a vast difference between ideas and their practical application. I have built and operated reverberatory furnaces and it was for this reason that it occurred to me, while I was engaged in some engineering work for the Cement Gun Co. that their machine could be used for the purpose indicated above. In my connection with the Cement Gun Co. I had an opportunity to study the development of the machine from the time it was first conceived by Mr. Ackley up to its present development, and I would say that the idea of blowing a solid against a surface is one thing and carrying out the idea is another.

Volumes could be written on the difficulty of doing

that very thing, and I myself have spent the better part of two years in solving the problems connected therewith. It can, therefore, be very easily understood that anyone merely wishing to apply this idea to furnace work, without having knowledge gained from experience, would run against great difficulties in a mechanical way. This is probably the reason why the matter has never been prosecuted farther.

A furnace built by this process whereby the proper screen combination is used to produce a mixture which can settle into place with practically no voids, would give enormous metallurgical advantages. The absorption of the bottoms would be reduced to a minimum, and with it, of course, the necessity of smelting old bottoms and placing new ones would be reduced in proportion. The furnace up-keep can not only be reduced to a low cost, but a furnace can be made to last practically indefinitely, because an absolute bond can be obtained between the material in place and the new material, and repairs can be made without interfering with the operation. Thus, if the proverbial "stitch in time" is applied whenever needed, the furnace should be kept constantly in first class repair with very little cost. If anyone wishes to try this process and is willing to go into detail, I would be glad to furnish any advice I am able to give as to details of operation.

Joplin, Mo. ALFRED SCHWARZ.

Metallurgical and Chemical Engineering in Great Britain

(By Our London Correspondent)

Concerning Things in General

All mental and industrial activity here (in London) is now dominated by one thing, and one thing only. The war and the demands incidental to it determine not only civilian occupations and movements, but our diverse pre-occupations. We talk very little about what we shall do when the war is done—although perhaps we are doing more "thinking ahead" about commercial and economic matters then than we were wont to do in the easy days when in their relentless, inevitable but unsuspected ways, uncontrollable forces were insuring the advent of a colossal war.

We are now mainly preoccupied with a very big problem—the national regrouping and reorganization of all activity. Save for those who wear the king's uniform here or in the field, there are before us here many questions centering round the fact that we must either answer them successfully or make way for a race with the brain to translate the co-ordinated activity of the ant-hill or the hive into the every-day facts of existence and racial persistence.

Individualism has played its part, and a very valuable part, in our development hitherto, but there has been a nemesis of individualism. When every man does "what seemeth right in his own eyes" without regard to discipline grave risks are run. Equally, too, superorganization with the elimination of individual thought or initiative has in it all the potentialities of atrophy and decay. Modern Germany, with all its wealth of organized knowledge, yet suggests in some degree a feeble imitation of the complex and highly organized civilization of the Incas. Safety obviously lies in avoiding the pitfalls on either side, and possibly some of its innate inclination for compromise will help the British race to surmount its obstacles.

The manufacture of rifles, field guns, cartridges, high explosives, aeroplanes, boots, uniforms, vehicles, and the feeding of the army is only one of many problems. The transport of men and munitions must be carried on simultaneously with the transport of foodstuffs and raw materials for the civil population. Military activity alone cannot suffice for any race barring, say, a race of freebooters content with an ephemeral existence of short but not necessarily jubilant span. Civilization demands synchronism between military effort and non-military activity when everything is referred to the arbitrament of the sword.

We are improvizing as we go along, and reckon to make a success of our improvization, although the cost of improvization will give us a bad national headache when the show is over.

Writing in a khaki uniform, one hesitates to prophesy. Yet your correspondent feels constrained to make a duplex prophecy which will fit either event that the fates yield to Europe. If militarism triumphs, it will be morally conquered by the adoption of a part of the individualism of the conquered nations. If the individualist and hitherto non-militarist races come out on top they, too, will be morally conquered by their adoption of semi-militarist tendencies and by an imitative co-ordination and national organization of the industrial activity of the race which they must now break or else be themselves broken.

Metallurgical Work at the National Physical Laboratory 1914-1915

The annual report of the National Physical Laboratory, now in my hands, is a chronical of diverse activities, all more or less influenced by the war. Twenty-five per cent of the staff—some fifty members—are now on military service, some of them in the same corps as your correspondent, doing similar garrison duties. Of course, the financial results of the year's work at the laboratory have been adversely affected by the war. Up to the end of June, the receipts for work done were considerably in excess of those for the corresponding three months of last year; during the next three months there was a heavy fall, amounting to some £2,100, but subsequently there has been a considerable recovery, the net result is that the accounts show a credit balance of £80.13.8.

So far as the present letter is concerned, I propose only to refer to the report of the department of metallurgy and metallurgical chemistry, leaving other matters for a later letter.

New apparatus has been added, including (1) a new vacuum pump—Gaede's piston type—for use in connection with the research on the melting point of iron in vacuo; (2) a large induction coil, intended primarily for use in connection with the cathode-ray furnace; (3) the remodelling of the plotting chronograph; (4) a microscope levelling device intended to supersede the older mechanical devices for setting the prepared surface of the specimen at right angles to the optic axis of the microscope; (5) an experimental rolling mill. This mill has been designed primarily for the purpose of providing facilities for rolling ingots of light alloys (alloys of aluminium) into bars and sheets for the purpose, in the first place, of ascertaining the suitability of various alloys for mechanical use, principally in connection with aeronautics, and, in the second place, for the purpose of determining the exact conditions under which various promising alloys can be rolled in a satisfactory manner. The mill, however, has been so designed that other alloys can also be handled in it. The need for an experimental equipment of this kind has arisen, in the first instance, from the circumstance that it has been found very difficult to obtain satisfactory rolling results in existing industrial mills with certain alloys which showed a high promise of usefulness. Although several bars of such alloys have been rolled by using extreme care and special precautions, it was quite

obvious that industrial success could not be obtained until the exact conditions demanded by the peculiarities of these alloys had been thoroughly studied. By equipping a full size rolling plant, in which the various conditions of speeds, draft and temperature are under exact control, it will be possible to ascertain within what limits these various factors must be kept in order to secure uniformly successful production. Experience has already shown that the conditions suitable for the rolling either of pure aluminium or of brass or steel are not satisfactory for these new materials.

Apart from these special questions, the rolling mill equipment promises to be of particular value for facilitating research on many questions connected with this important manufacturing process, since measurements of power, temperature, etc., can be carried out in the laboratory plant in a manner quite unattainable in most existing industrial establishments.

As regards research work, this was almost entirely confined to the first three or four months. After the outbreak of the war, this department was so short handed that it was found difficult to do much more than cope with the investigatory test work. The work actually done referred to the constitution of the Aluminium Zinc-Copper series. Considerable difficulty has, however, arisen in interpreting the indications of thermal curves and of microscopic examination relating to the alloys lying near the aluminium corner of the ternary triangle. This difficulty has now been traced to the fact that the accepted constitutional diagram for the copper aluminium alloys containing 90 per cent of aluminium and over is incomplete in regard to an important reaction which occurs in the alloys at a temperature of 560 deg. C. It has, however, been found difficult to discover the exact nature of this reaction, and since it is of fundamental importance to the understanding of the ternary alloys containing up to 5 per cent of copper, considerable time has been devoted to the study of this special point. This difficulty is an example of a class which is frequently met with when ternary alloy systems come to be investigated in an accurate manner. It is then frequently discovered that a very minute transformation which occurs in one of the binary systems has escaped observation, but that the evidences of this occurrence, such as thermal arrest points and microscopic changes, become considerably intensified by the addition of a few per cent of the third metal. Although in themselves of considerable interest, the discovery of these points often requires a very extensive investigation before the work on the ternary system can proceed satisfactorily, so that the labor—already very extensive—of investigating ternary systems is thereby very largely increased. It is, however, considered that the studies of ternary systems undertaken at the laboratory should not be merely of an approximate or exploratory nature, but the full treatment necessarily involves considerable delay in the attainment of results suitable for publication. This is the principal reason why it has not been found possible to issue a further alloys research report during the past year. It is hoped, however, to carry the work to a stage where publication becomes possible before the end of the present calendar year.

Experiments on the physical properties of the ternary alloys have been largely postponed until the rolling of the alloys could be carried out in the experimental rolling mill at the laboratory itself. A large number of ingots for the purpose of carrying out these rolling experiments have, however, been prepared, and as soon as the equipment of the mill is complete a large quantity of results will rapidly become available.

The scheme for the extended investigation of the permanence of light alloys in regard to supposed spontaneous disintegration, which was set out in the previous report, has been steadily pursued as far as the adverse circumstances already noted have permitted. The preparation of the very large number of test pieces has proceeded and is now approaching completion, while a considerable number of measurements have been made.

Other research work has included some work on low carbon steel as to the effects of strain at high temperatures, on the intercrystalline cohesion of metals, on the melting point of iron. With reference to Dr. Rosenhain's new re-agent for etching steel, it is pointed out that an example of the usefulness of this re-agent has recently occurred in connection with steel required for war materials. In this steel, minute cracks and fissures, which inevitably led to the rejection of the final product, have been found to be definitely associated with the presence of phospheric bands, whose presence was clearly revealed by the re-agent. A further interesting observation, which has been carefully confirmed, illustrates the manner in which the phospheric banding of steel persists even after drastic heat treatment. This observation was made by examining a banded steel in the ordinary annealed condition and again after quenching from 800 deg. C. In the latter condition, while the bulk of the steel was in the condition of martensite-troostite, certain regions were found to consist of ferrite, and this could readily be identified with the bands of phospheric ferrite revealed by the new re-agent in the annealed steel. This observation shows clearly how the presence of a relatively high proportion of dissolved phosphorus prevents the diffusion of iron carbide even at a temperature as high as 800 deg. C. A further inference may be drawn to the effect that the presence of marked phosphorus banding is a very serious disadvantage to steels which have to be hardened, and incidentally also to materials intended for case hardening, since phosphoferrite resists diffusion of carbon, and this leads to the production of soft spots, and even of cracks, after hardening.

Reference is also made to the Research on Magnet Steels conducted under the auspices of the Research Committee of Magnet Steel.

A detailed study of the constitution of the Alloys of Copper and Tin has been begun with a view to utilizing the most accurate available methods for clearing up the points which still remain in doubt in regard to the constitution of these alloys.

The work so far undertaken has dealt with alloys containing 55 to 65 per cent of tin, and the results have been published in a paper read at the March (1915) meeting of the Institute of Metals. Incidentally, for the purposes of this research, a new form of thermostat has been developed (Mr. Haughton and Mr. Hanson), which allows specimens to be annealed in electrically heated furnaces for long periods at a temperature maintained constant within + 1 deg. C. As yet the apparatus has only been constructed of glass, and is, therefore, only available up to a temperature of about 450 deg. C., but it is hoped to extend its usefulness by having it constructed in silica, or, possibly, even in metal. It will then be very useful in the metallographic study of many alloy systems.

There has been much activity in regard to investigatory test work. The work which has been carried out may be roughly divided into three groups:

(1) Investigation of cases of failure.

(2) Investigations in connection with manufacturing processes, the manufacture of specific articles, or the use of special materials.

(3) Investigations connected with aeronautics.

Cases coming under group (1) have been more numerous than usual. The examples dealt with cover a very wide range of metals (ferrous as well as non-ferrous)

and a wide range of objects. As regards group (2), while several of the cases ivestigated have been those arising out of industrial difficulties of an ordinary nature, several have arisen, during the last few months from circumstances due to the industrial conditions caused by the war. The laboratory has been, in several instances, in a position to overcome the difficulties of manufacturers arising from shortage of customary materials, etc. Owing to the confidential character of the work of this kind detailed reference to it is obviously impossible.

The investigation of failures and breakages occurring in connection with aeronautical work, principally in regard to engine parts and in some cases structural parts of aeroplanes, has occupied a very large amount of time and attention from the superintendent and staff of the department. Particular attention has been devoted to the question of the effect upon steel of acetylene welding, and the research which has been undertaken in consequence of the questions raised in this connection is being carried out jointly with the engineering department. The materials involved in these aeronautical questions are in many cases special alloy steels of peculiar properties and microstructure. The peculiarities in question have in many cases required special experimental investigation; so much so is this the case, that it is becoming desirable that a systematic study of the more usual types of alloy steels should be undertaken by the department, and, as indicated in the outline program for future work, it is hoped to undertake such a systematic study as soon as the pressure of the work of the staff of the department may permit.

Market Prices

JULY, 1915

Copper opened at £82, and fell rapidly to £79.10 (2nd), recovered to £80 (6th), then declined to £78 (12th), and after a slight improvement to £78.10 (13th), it fell away to £74.15 (18th); it then rose to £76 (21st), and after declining to £75 (23rd), fell sharply to £72 (25th), recovered slightly to £72.10 (26th), and continuing to fall closed at £71.10.

Tin opened at £172.10, falling to £171 (2nd). It then improved to £173 (3rd), declined to £170.10 (8th), and after again touching £173 (13th) fell rapidly to £165 (20th). After a slight recovery to £166 (21st), it continued to fall steadily, closing at £155.

Haematite opened at 95/- and remained at this price throughout the month.

Scotch Pig opened at 72/6, improving to 74/- (7th). It then declined, again reaching 72/6 (20th), and after recovering slightly to 73/- (22nd), continued to fall to 72/3 (27th), after which it remained fairly steady, closing at 72/6.

Cleveland opened at 66/6, improving to 67/6 (2nd). After a slight decline to 67/3 (3rd), it continued to rise to 68/- (7th). It then fell slowly again, reaching 66/6 (20th), recovered to 67/- (22nd), but afterward lowered to 66/3 (27th). It then improved slightly, closing at 66/6.

Lead opened at £26.15, and after falling away to £25 (8th), it recovered to £26.5 (26th), at which price it remained steady till the 15th; it then declined to £25.15 (16th), and again remained steady till the 24th, after which it continued to fall, closing at £24.10.

	£	s.	d.
Borax, per ton	22	0	0
Copper sulphate, per ton	28	0	0
Caustic soda, 70 per cent. per ton	10	2	6
Hydrochloric acid, per cwt		4	6
India rubber, Para, fine, per lb		2	6½
Mercury	18	10	0
Sal Ammoniac per cwt	48	0	0
Shellac, per cwt	3	5	0
Platinum, per oz	9	5	0
Ebonite rod, per lb		3	0
Sulphur, sublimed flowers, per ton	11	10	0
Mica in original cases, medium, per lb		5	0

Notes

Electrolytic Oxygen and Hydrogen.—The International Oxygen Company, 115 Broadway, New York City, has issued a 24-page booklet on "I. O. C. System, Production Pure Oxygen and Hydrogen." It deals with the I. O. C. system of welding and cutting and is profusely illustrated, showing installations in various parts of this country and abroad.

Converter practice at Hayden, Ariz., has given the following results, according to Manager J. J. Ormsbee: Throughout November, 1914, a daily average of over 81 tons of copper was produced from a 42 per cent matte, with a standard size Pierce-Smith converter. During the first half of February, 1915, a daily average of 85 tons was maintained.

The Dome mill, at Porcupine, established a new record in May, when 26,000 tons of ore was treated, having an average value of $4.28. The gold produced was valued at $111,261. This tonnage is the largest in the history of the mill; the value was approximated in April, when it was $4.20 per ton.

The Ohio Copper Company's mine and mill at Bingham and Lark, Utah, have been leased to the General Exploration Co., of Salt Lake City. The mill will be put in condition to handle 2000 tons of ore daily.

Stratton's Independence, Ltd., treated during the month of April 8387 tons of low-grade dump and mine ore, netting the company $8,000.

Porcupine Crown Gold Mining Co. is preparing to retreat the tailings from its experimental amalgamation mill. The dump contains about 19,000 tons valued at $3.50 per ton, and was accumulated prior to the erection of the cyanide mill.

The Tropenas Converter Co., of 50 Church St., New York, is erecting a new office and laboratory building of its own in Brooklyn, N. Y. This will include a small experimental plant in which a novel steel-producing method is to be perfected.

The Bucyrus Company, of South Milwaukee, Wis., has moved its Southern sales office from Birmingham to New Orleans, La. Mr. E. L. Byron, Southern sales manager, will remain in charge, and will have associated with him, Mr. R. S. Byron. His office will be 1105 Hennen Building.

The price of ferromanganese in the United States fluctuated widely in 1914, on account of the European war. Prior to August the price of standard 80 per cent ferromanganese was about $40 a long ton. During August prices ranged from $110 to $140 a ton, while quotations dropped as low as $62 in November and advanced again to $80 in December.

The establishment of platinum refineries in Russia has not been encouraged as a result of the order forbidding the exportation of platinum in quantities valued above 500 rubles ($257.50). Not a single refinery has been opened, and producers find themselves with large quantities of metal on hand which they cannot market. The bureau for gold and platinum industries has been asked to ascertain whether sales can be effected in this country, and if so the producers will ask for a modification of the embargo. Representatives of the gold mining industry in Russia have petitioned the government for the establishment of a concern to manufacture potassium cyanide.

Tanks.—The Walter A. Zelnicker Supply Company of St. Louis has sent us its recent bulletins on used tank car tanks.

The Link-Belt Company, of Chicago, has issued its new Portable Wagon Loader Catalog 210, which de-

scribes the machine that will load a wagon or truck with material carried on the ground at the rate of one ton per minute.

Gas and Gasoline Engines.—The Chicago Pneumatic Tool Co. has issued a bulletin describing their class A-G Giant Engines for the utilization of natural or producer gas or gasoline.

DeLaval Centrifugal Blowers and Compressors are described in a catalog recently issued by the DeLaval Steam Turbine Company of Trenton, N. J. This is a profusely illustrated catalog containing illustrations, diagrams, and descriptions of their products.

The Mesta Machine Company of Pittsburgh reports a recent shipment of a four-arm low-type sheet pickling machine to the Alan Wood Iron and Steel Co., Philadelphia, and orders from the McKeesport Tin Plate Company for three of these machines.

Costs in the Steel Foundry is the title of Steel Castings for July, 1915, a small bulletin issued by the Tropenas Converters Company. This bulletin discusses costs systems and gives special attention to overhead costs and the determination of selling prices.

The Snyder Electric Furnace Co. of Chicago is installing a Snyder steel furnace for the Canadian Brakeshoe Company, Ltd., of Sherbrooke, Quebec. This furnace will melt and refine cold material and will deliver 24 tons in 24 hours.

Glass Enameled Products.—The Elyria Enameled Products Company of Elyria, Ohio, has issued Catalog *B* describing seamless one-piece enameled apparatus. This includes open and closed tanks, steam and water jacketed kettles, vacuum pans, etc. The glass enamels used are claimed to be acid, alkali, and rust resistant, and the seams are welded by the autogenous welding process.

The National Screen Separator is described in a bulletin recently issued by the National Engineering Co. of Chicago. The feature of this separator is a device for keeping the screen from clogging up. This is accomplished by having wires stretched underneath the screen which are alternately drawn taut and released by suitable mechanism, thus forming a vibrating devise striking the screen.

Conductivity of Electrolytes.—The accurate measurement of the conductivity of electrolytes is discussed, and improved apparatus for this purpose described, in catalog No. 48 recently issued by the Leeds & Northrup Company, Philadelphia, Pa. The development of this apparatus was made with the assistance of Dr. E. W. Washburn of the University of Illinois. The catalog contains, besides the description of apparatus, much valuable technical information on conductivity measurements, comprising about 29 pages of discussion, diagrams and illustrations.

The **National Tube Company**, Pittsburgh, Pa., has issued Catalog J, comprising material manufactured at the Kewanee Works of the National Tube Company, embracing "National" pipe for steam, gas, water and air; cast iron, malleable iron and brass fittings; "Kewanee" unions and "Kewanee" specialties; brass and iron body valves and cocks; radiators and coils; drive well points and well supplies. The catalog is a beautifully illustrated volume of 394 pages, and very elaborate and detailed in its information, giving lists of the different sizes of the materials manufactured, with drawings and in part colored illustrations.

The debt of Chilean nitrate producers to the government on May 15, as a result of loans advanced by the government to keep the industry going, amounted to $2,880,000.

Ultraviolet Rays.—A reference list of 317 articles, etc., on ultraviolet rays, available in the New York Public Library has been published in form of a pamphlet by this Library.

The output of recoverable zinc in New Jersey in 1914 was 148,506,500 lb., as compared with 144,312,560 lb. in 1913. Owing to the lower average price of spelter, the estimated value of the 1914 product was only $7,515,914, as against $8,081,502 in 1913.

Antimony shipments from Central China during the first three months of 1915, according to the Hankow *Times*, consisted in 1067 tons of antimony regulus and 2560 tons of crude antimony. The price for regulus has practically quadrupled since last August, and the high price has greatly stimulated production.

The production of Portland cement in the United States in 1914 was 88,230,170 barrels, valued at $81,789,368, according to the U. S. Geological Survey. The output represented a decrease in quantity of 3,866,961 barrels, and a decrease in value of $10,768,249, as compared with 1913.

A Government Corner in Chinese Blue.—According to a Washington newspaper story, Mr. Joseph E. Ralph, director of the Bureau of Engineering and Printing, has bought up in New York all the available supply of Chinese blue and other special colors needed in the preparation of stamps, seals and paper money.

Methods of determing total sulphur in rubber have been studied by the Bureau of Standards. The results have been published in Technologic Paper No. 45, recently issued. Copies may be had free of charge on application to Bureau of Standards, Department of Commerce, Washington, D. C.

The ash of the seaweed collected on the shore of Manila Bay in Tondo is reported to yield 15 per cent of potash. No data are available to show the quantity of seaweed that can be gathered, but it is considered to be abundant. The discovery has aroused considerable interest owing to the present scarcity of potash.

The American Shop Equipment Co. of Chicago has issued a bulletin on Shop Furnaces describing their rivet forges for oil or gas fuel, flue welding furnace and forge furnaces, also heat treating furnaces and pot furnaces, all for oil or gas fuel. The bulletin also gives complete export shipping data.

The Hardinge Conical Mill Co. is installing for the Nevada Consolidated Copper Co. two 8-feet dia. Hardinge mills, to be used with iron balls. Also an order from the Dome Mines Co., Ltd., of South Porcupine, Ont., Canada, for two 8-feet dia. ball mills. These ball mills are to take the place of stamps now in use at the Dome Co.'s plant.

The **Superior Chemical Corporation** has recently been organized, with factory and office at 170 Tillary Street, Brooklyn. The officers are John E. Muhlfeld, president, and Samuel G. Allen, secretary and treasurer. The operation of the plant will be under the supervision of J. L. Danziger. The company will manufacture chemical and allied products, with especial attention devoted to photographic developers.

Natural Gas.—The Bureau of Mines has just issued Technical Paper 109, which deals with the chemical and physical properties of the natural gases used in twenty-five cities in the United States. The authors are G. A. Burell and G. G. Oberfell. Five of the samples contain methane only, as the combustible gas. The others contain in addition to methane higher members of the series of paraffin hydrocarbons. The heating values range from 735 to 1312 B.t.u. per cubic foot at 0 deg. C. and 760 m.m. pressure.

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Seattle Meeting of the American Chemical Society

THE fifty-first meeting of the American Chemical Society was held at Seattle, Washington, from Tuesday, Aug. 31, to Friday, Sept. 3, and proved unusually successful and enjoyable. It was a somewhat "old-fashioned" meeting in the best sense of the word, with a preponderance of general meetings over sectional sessions, with the attendance always held well together, and a true, congenial happy spirit prevailing all around.

Immense credit is due to the local committees, with chairmen H. G. Byers of the executive committee, H. K. Benson of the finance committee, E. J. Bartels of the excursions committee, L. A. White of the press committee, J. H. Linton of the reception and registration committee, R. W. Clough of the banquet committee, M. J. Falkenberg of the smoker committee, and Mrs. C. A. Newhall of the ladies' committee. With Seattle extending its fullest hospitality to the society everyone felt at once at home. But for the fine and truly happy spirit which prevailed full credit must also be given to the president of the American Chemical Society, Dr. Charles H. Herty, who impressed his charming personality on the whole meeting and even succeeded in eliciting some excellent and lively discussions in the technical sessions.

The attendance during the general meetings was nearly 200. From the East a party of about forty members had come in a special car personally conducted by President Herty and Secretary Parsons. A stay at Glacier National Park on Saturday and Sunday, preceding the Seattle meeting, was delightful. The party arrived at Seattle on Monday. Simultaneously another party of a score of members arrived in countercurrent from San Francisco, having attended the meeting of the American Institute of Chemical Engineers the week before.

On Monday night there was a meeting of the council of the American Chemical Society, preceded by a complimentary dinner. The general meeting started on Tuesday morning in the chemical laboratory of the University of Washington with general registration. The registration officials were not only charming to look at, but the office had a 100 per cent efficiency as a semipermeable diaphragm. Members having registered and received the very pretty totem-pole badges found themselves in the lecture room, with no way left to the outside. And the meeting that followed was enjoyed by all in fullest measure.

Open Meeting

The meeting was opened by Dr. H. G. BYERS, professor of chemistry at the University of Washington. He introduced Dean ARTHUR PRIEST, who as personal representative of the president of the University and of the Mayor of Seattle extended the welcome of university and city to the society in a felicitous little speech.

Dr. CHARLES H. HERTY, president of the American Chemical Society, in his reply referred to the reception which the society had from the Seattle section five years ago on its Western trip. He spoke of the Pacific Coast as a land that has been built by "boosters" in the best sense of the word. The confidence in the future of this country is our rich inheritance from the pioneers who built up the empire at the Pacific Coast. Dr. Herty paid a tribute to the daily newspapers of Seattle which show so much interest in science and industry in general and in the University of Washington in particular, and as newspapers give the people what they want, this fact proves the great interest which the people of the State of Washington take in their University. Dr. Herty concluded with a reference to the great developments right before us now and the immense opportunities of the American chemist. Mutual helpfulness must be the keyword.

CHEMICAL INDUSTRY

The opening address related to "Chemical Industry," the author being Dr. L. H. BAEKELAND. In his absence the address was read by the secretary, Dr. Parsons. As this address is to be delivered again next week by the author himself in connection with the National Exposition of Chemical Industries, in New York, we reserve its publication in full to our next issue.

Dr. Baekeland referred to the present European war as a chemists' war. But "do not imagine that this is the first chemical war. The art of kiling and robbing each other became chemical the day gun powder was invented; at that time, however, the existing knowledge of chemistry was just of pinhead size. Napoleon knew very well how to use adroitly exact knowledge and chemistry for furthering his insatiable ambition to dominate the world; so he surrounded himself with the most able chemical advisers and scientists. Ever since then science, technology and chemistry in particular have played a rôle of increasing importance in the armament of nations. . . .

"Do not reproach chemistry with the fact that nitrocellulose, of which the first application was to heal wounds and to advance the art of photography, was stolen away from these ultrapacific purposes for making smokeless powder and for loading torpedoes. Do not curse the chemist when phenol, which revolutionized surgery, turned from a blessing to humanity into a fearful explosive, after it had been discovered that nitration changes it into picric acid.

"Let us hope in the meantime that war carried to its modern logical gruesomeness, shorn of all its false clamor, deceptive picturesqueness and rhetorical Bombast, exposed in all the nakedness of its nasty horrors, may hurry along the day when we shall be compelled to accept means for avoiding its repetition."

After his introductory remarks on the war, Dr. Baekeland reviewed the peaceful work of the chemists in the industry, especially the work of the American chemists who, he emphasized, are a more potent factor in the world's progress now than those of Germany or England. He emphasized the importance of the achievements of American electrochemical industries, compared with which the dyestuff industry is almost insignificant. He defended in a strong and able manner the American chemist against the claim that he was to be blamed for the lack of an American dyestuff industry.

But Dr. Baekeland also agreed that in the past, chemists, as a general rule, had been too much analytical and not enough constructive. "Successful engineering is essentially constructive. The most urgent work for the chemist of to-day must be constructive—he must learn how to cement together the vast amount of data which already lie at his disposal, even if he, himself, has to produce this very cement by further research."

THE PACIFIC NORTHWFST

Dr. H. K. BENSON, of the University of Washington, followed with an address on the "Industrial Resources and Opportunities of the Pacific Northwest." This address is published in full at the end of this report.

SYMPOSIUM ON THE CONTRIBUTIONS OF THE CHEMIST TO VARIOUS AMERICAN INDUSTRIES

After these two addresses of general interest, the symposium of papers on contributions of the chemist to various American industries was taken up, in continuation of the series of papers presented at the New Orleans meeting (this journal, May, 1915, p. 283).

JOHN E. TEEPLE'S paper on "The Contributions of the Chemist to the Naval Stores Industry" was read by Professor Frankforter.

GEORGE W. SARGENT'S and A. L. CUSHMAN'S two papers on "The Contributions of the Chemist to the Iron and Steel Industry" were read by Professor Franklin.

M. H. ITTNER'S paper on "Contributions of the Chemist to the Art of Soap Making" was read by Dr. Richardson.

E. T. BEISER'S paper on "Contributions of the Chemist to the Perfumery Industry" was read by Dr. Byers.

G. W. THOMPSON'S paper on "Contributions of the Chemist to the Lead Industry," was read by Professor Withrow.

MAXIMILIAN TOCH'S paper on "Contributions of the Chemist to the Paint and Varnish Industry" was read by Dr. Parsons.

Dr. JOHN R. M. KLOTZ, chief chemist of the Barrett Manufacturing Company, then presented a very interesting paper on "Contributions of the Chemist to the Coal Tar Industries," which we reserve for publication in full in our next issue. This paper elicited an extended and lively discussion in which Dr. Klotz gave additional information on the particular conditions of this industry created by the war.

Mr. R. F. MAX MICHAEL then read an illustrated paper on a new viscosimeter.

The balance of the program for this afternoon comprised the following three papers:

FRANCIS C. FRARY, "Contributions of the Chemist to the Photographic Industry."

FRANK R. ELDRED, "Contributions of the Chemist to the Pharmaceutical Products Industry."

S. W. KATZENSTEIN, "Contributions of the Chemist to the Hardwood Distillation Industry."

Sessions of Wednesday

While the afternoon of Wednesday was devoted to section meetings, the forenoon was given over to a very interesting symposium on wood distillation in general session.

Professor JAMES R. WITHROW of Ohio State University gave an illustrated lecture on "Chemical Engineering Features of the Hardwood Distillation Industry. Dr. S. F. ACREE of the Forest Products Laboratory of Madison, Wis., discussed "What Chemistry Had Done to Help the Utilization of Wood."

The other papers on the program for this session were:

H. K. BENSON and T. G. THOMPSON, "The Study of the Tannin Content of Douglas Fir Sawmill Waste."

H. K. BENSON and MARC DARRIN, "Yield of By-Products from the Destructive Distillation of Some Western Conifers."

H. K. BENSON and NEWTON CRITES, "The Extraction of Resinous Wood by Ammonia."

ROY C. JUDD, "Discoloration of Maple in the Kiln."

R. E. ROSE and A. G. BISSELL, "The Chemical Composition of the Light Oil from the Destructive Distillation of Resinous Woods."

F. W. KRESSMANN, "Manufacture of Ethyl Alcohol from Wood Waste. II. The Hydrolysis of White Spruce."

HOMER CLOUKEY, "The Application of the Davis Spot Test in the Preliminary Examination of Creosotes."

A. W. SCHORGER and RALPH SAYRE, "Isoprene from Beta-pinene."

BAILEY TREMPER, "The Distillation of Douglas Fir at High Temperatures."

F. W. KRESSMANN, "The Manufacture of Ethyl Alcohol from Wood Waste: III Western Larch as a Possible Raw Material."

MARC DARRIN, "The Production of Acetone from Pyroligneous Acid."

An account of this symposium is reserved for our next issue.

PRESIDENTIAL ADDRESS

Dr. CHARLES H. HERTY'S presidential address on "Co-operation in Matters Chemical," delivered on Wednesday evening, was one of the ablest presidential addresses delivered before the American Chemical Society.

Dr. Herty pointed out how regrettable it was that the three-year-old determination of international co-operation of chemists, conceived at the International Congress of Applied Chemistry in New York City in 1912, had so early been forgotten, due to the war.

Research, whether "pure" or "applied," is identical. Pure enrichment means enrichment of the soil, applied research means crop production. There is no dignity or lack of dignity involved. "Pure" and "applied" research are just terms of convenience.

Dr. Herty emphasized the responsibility of professors of chemistry in universities, especially head professors, in bringing out the national point of view, through their attitude toward research.

The war situation has called public attention too acutely to certain special applications of chemistry, at the expense of the deserved appreciation of the quiet workers who have in the past built up our science.

Dr. Herty made a plea to all chemists for some little research with no hope of pay so that all of us may thus repay our obligation to our science.

University research should be greatly encouraged. This raises the question whether there exists the proper co-operation between the universities and the industries.

Do university professors have the proper attitude toward the problems of the industry? Do they emphasize sufficiently "chemistry in service of mankind?"

On the other hand, do men in the industries appreciate properly the rationale of the university professor's point of view in establishing fundamental facts and drawing accurate deductions therefrom?

Dr. Herty emphasized the stimulating and broadening influence of the general meetings of the American Chemical Society held in different parts of the country. He warned against the dangers of local sectionalism in the society.

Chemical preparedness for national defense puts an important responsibility upon the chemist, who derives in return the valuable benefit of the proper development of certain needed industries which might otherwise be neglected.

That the nation should be self-contained is a matter of most fundamental importance.

Our visible supply of sodium nitrate is slight. We have depended too much on Chile saltpeter and perpetual peace. We should acquire, with government help, a sufficient supply to tide us over an extra year until factories could makes nitrates from air in case of war.

Ammunition is important enough, but have we acquired chemical preparedness in industrial chemistry?

Dr. Herty then discussed our patent system and where it is deficient. He called attention to the failure of the nation to understand the asset value of a patent and to the failure to protect him who creates. The nation, through its laws, should be the guardian of the patentee.

Dr. Herty mentioned the throttling of the early aniline oil industry in this country by foreign competition. He emphasized the viciousness of dumping and the necessity of the adoption by Congress of an anti-dumping clause.

Dr. Herty pointed out the value which an American dyestuff industry would have as a reserve for the explosive industry.

In concluding his able analysis of the present industrial chemical situation in this country, Dr. Herty emphasized that the chemist has made good. What we need is wise legislation.

Social Functions and Entertainments

The entertainment program was delightful.

The special program for the ladies contained an extensive automobile trip, a theatre party, and a fine exhibition of folk dances by co-eds of the university.

The Council was entertained at a complimentary dinner on Monday night.

The feature of the smoker given to the Society on Tuesday evening at the Seattle Commercial Club was an illustrated lecture by Professor Edmond S. Meay, president of the Mountaineers, on Mount Rainier. There were also some vaudeville entertainments and the whole occasion was greatly enjoyed.

On Wednesday afternoon there were automobile rides, on Thursday a fine excursion on Puget Sound for the inspection of the shipping and fishing industry, and a banquet in the evening of Thursday. As the writer had already left Seattle, he is unable to say from his own experience how the following feature of the banquet program, quoted from the Seattle *Daily Times*, worked out: "So that the local chemists will have a little first-hand information on the quality of the beverages to be consumed after the prohibition law goes into effect in this State, a number of 'wines' and other non-alcoholic drinks, invented by the local chemists, will be served to the visiting scientists at a dinner to be given in their honor at the Hotel Washington on Thursday evening. The sub-committee, Charles A. Newhall and Professor Benson, thought this would be a good opportunity to ascertain from the members of their own profession whether the new concoctions have any 'pep.'"

After completion of the Seattle meeting, the program provided an excursion to Mount Rainier National Park, a visit to Portland, Ore., with luncheon and excursion on the Columbia River, the party being the guests of the Oregon Section, and finally at San Francisco, an entertainment by the California Section at a smoker at Techau Tavern. Dr. Franklin and Dr. Duschak had come from San Francisco, to welcome the society to California.

* * *

The Industrial Resources and Opportunities of the Northwest

An Address Made at the Seattle Meeting of the American Chemical Society

BY H. K. BENSON

In an address* upon a similar topic dealing with the Southern States, our mutual friend and co-worker, A. D. Little, expressed his temerity for a visitor to enumerate the potentialities of the South. For an entirely different reason the speaker faces a similar temerity. Inasmuch as he must remain in the locality after the attendants of the convention have departed, he must stay with the facts and representations here made. If, therefore, the figures are not as large and the possibilities not as boundless as those to which you became accustomed at the New Orleans meeting, your disappointment must be attributed to the fear, and not to the enthusiasm, of the speaker. In the brief compass of this address it is hoped, however, to call attention to the great store of natural resources and latent opportunities for development which constitute the heritage of those who labor in the Pacific Northwest.

The industrial aspect of the Northwest has been toward the East. From thence flowed the great streams of capital which have furrowed the conti-

*This journal, May, 1915, p. 281.

nental barriers and spread a network of transportation to every storehouse of natural treasures; or locked in mountain fastnesses have generated the power with which the wheels of industry may be driven. The time is coming and is now here when we may well turn from the broader phases of external development to a more minute and critical inspection of the resources about us on every hand and utilize them in the greater intensification of industry and commerce.

The Pacific Northwest constitutes an industrial unit which comprises the States of Oregon, Idaho and Washington, the province of British Columbia in Canada, and the territory of Alaska. Although composed of different political parts, whereby the natural course of industry may be hindered or benefited, yet the ultimate outlet for commodities is largely confined to the cities touching the waters of the Pacific Ocean. Material development of any portion of this area is felt throughout all of it. While it would be of great interest to comprehensively discuss the potentialities of the Pacific Northwest as a whole, the lack of published data would make it necessary to collect and compile at first hand much of this information. Time does not permit of such an extended investigation of this at present, and it is proposed therefore to present in some detail the resources of the State of Washington as a typical example of what may be found in varying degrees throughout the entire Pacific Northwest.

The total area of the Pacific Northwest includes nearly a million and a quarter square miles distributed as follows:

Oregon	96,607	sq. mi.
Washington	69,180	" "
Idaho	83,888	" "
British Columbia	395,500	" "
Alaska	586,400	" "
	1,234,575	sq. mi.

Harney County alone, in Oregon, contains as much tillable land as the State of Maryland, while the area of Alaska is greater than that of Norway, Sweden, Finland, England, Scotland and Ireland taken together. While a large portion of Alaska is mountainous, less than 1 per cent of its area consists of permanent snow fields, and its agricultural valleys contains as much tillable land as is cultivated in the States of New York, Pennsylvania and Ohio.

LUMBER INDUSTRY

We call Washington the "Evergreen" State, because its hills and mountains are enveloped with forests of fir, cedar, spruce and hemlock. With the pines of Oregon and Idaho, these forest species represent the greatest resource of the Pacific Northwest. In the States of Oregon, Washington and Idaho there are still uncut more than 50,000,000 acres of merchantable timber, from which it is estimated that over 850,000,000,000 ft., board measure, of lumber may be cut. This is more than one-third of the standing timber of the United States. The annual cut of lumber in the two States of Oregon and Washington is slightly in excess of 5,000,000,000 ft. in lumber and 8,500,000,000 shingles. Over 2000 wood manufacturing establishments, employing about 65,000 men are required in the production of the lumber and timber products of Oregon and Washington annually. The value of the timber product annually manufactured exceeds $80,000,000, of which 80 per cent is paid out for wages, taxes, rent and other production costs. When there is added to these forest areas, the 180,000,000 acres of forest lands in British Columbia with its annual cut of 1 1/3 billion ft. and an estimated stand of merchantable timber amounting to 130,000,000,000 ft. and the more or less indefinite content 20,000,000 acres of merchantable timber in Alaska, it becomes apparent that the timber products of the Northwest will continue for many years as an asset of great importance.

FERTILIZER INDUSTRY

The fertilizer resources of the Pacific Northwest are almost of equal importance as its forest products. From the waters of Puget Sound and the North Pacific the annual harvest of fisheries products exceeds $53,000,000. In 1913 the fisheries products of British Columbia were almost one-half of the total production of the Dominion, amounting to $14,500,000, and twice the value of those of Nova Scotia. The salmon industry of Alaska now extends from Ketichan in Southeastern Alaska for a distance of 2000 miles to beyond Bristol Bay in Bering Sea. In 1913 the seventy-nine salmon canneries of Alaska represented an invested capital of $31,341,670, and the annual catch of halibut, codfish, herring and whales requires an additional investment of over $6,000,000.

From the annual packing of 8,000,000 cases of salmon on the Pacific Coast results an annual production of 140,210 tons of cannery waste, which might be augmented considerably by the non-edible fish which are rejected and never reach the cannery. This waste contains in the fresh condition 10 per cent oil, 3.5 per cent bone phosphate, 1.5 per cent phosphoric acid and 3 per cent nitrogen. Of the total waste in 1913, only 16,300 tons were utilized on the Pacific Coast of the United States. From this waste were obtained 1630 tons of dry scrap and 293,000 gal. of oil. More complete utilization would increase the possible output of fertilizer and oil by tenfold.

Floating upon these same waters are the great beds of the giant kelps or seaweeds. These have been mapped by the United States Bureau of Soils, and according to this survey they yield annually over 20,000,000 tons of kelp equivalent to 750,000 tons of potassium chloride. The total imports of potash salts of all kinds in normal time is equivalent to about 400,000 tons annually. From the kelps of the North Pacific waters may be extracted not only the potash salts for domestic consumption but a surplus as well, which eventually may enable this country to export potash salts to other countries.

Until the discovery of the rock phosphate deposits of the Northwest the only commercial quantities that were known to exist in the United States were found in Florida and Tennessee. The phosphate deposits of Idaho are thirty times greater than the other known deposits of the United States. In the areas thus far surveyed by the United States Geological Survey it is estimated that over 2,500,000,000 tons of phosphate rock with 35 to 37 per cent phosphoric acid (P_2O_5) may be found.

In the ultimate utilization of cannery waste and of non-edible fish, of the potash in kelps and of phosphate rock, the Pacific Northwest offers a most promising field for the upbuilding of a great fertilizer industry.

COAL AND OIL

In the past the industrial welfare of a community was dependent upon its nearness to a coal deposit, but in the Northwest coal has competitors in the great quantities of oil from California and the electrical power of the mountain streams of the Northwest. The annual production of coal in the State of Washington is nearly 4,000,000 tons, while that of British Columbia is 2,500,000 tons. The total supply of coal in

the Pacific Coast States is estimated by Campbell and Parker at 22,000,000,000 tons, of which 20,000,000,000 are located in the State of Washington. The coal fields of Alaska cover 12,667 square miles. The estimate of the Geological survey places minimum coal resources of Alaska at 150,000,000,000 tons, which are far in excess of the original coal supply of Pennsylvania. Unlike the latter, however, much of this coal consists of lignites, the utilization of which calls for new methods and processes. Even in the State of Washington and adjacent to the coal fields themselves fuel oil is transported from California displacing annually a quantity of coal greater than that consumed.

WATER POWER

The water power resources of the Pacific Northwest constitute an important factor in power productions. The estimated developed water power of the Pacific Northwest exclusive of Alaska, exceeds 650,000 hp. The estimated undeveloped power of the Columbia River Basin is approximately 20,000,000 hp. or one-third of all the undeveloped water power in the United States, and equivalent to all the water power found in the twenty-six States east of the Mississippi River. Within economical transmission of our larger cities on tide water may be generated at least one-fifth of the available water power of the United States, exclusive of Alaska. The water power resources of the latter are said to exceed those of the Pacific Coast States.

MINERAL INDUSTRY

Much has been written of the mineral industry of Alaska and the Northwest, and it would become tedious to particularize concerning its extent and importance. The annual production of gold and silver in normal times is approximately $35,000,000. For the year 1913 the production of copper was valued at $11,300,000, of lead at $15,600,000, and of zinc at $2,500,000. The development of deposits of minor minerals has not been extensive, due to their remoteness from suitable smelting facilities. On the Seward Peninsula is a tin-bearing district of 450 square miles. Alaska has produced since 1902 over 560 tons of tin. Antimony ores are found in Alaska and Washington, molybdenum in British Colombia and Washington, tungsten in Alaska and Washington, while platinum is found in the sluice boxes of many of the placer camps of Alaska. Arsenic ores abound in the Monte Cristo district of Washington, and are smelted with the recovery of white arsenic at the Tacoma smelter.

Graphite, gypsum and barytes exist in commercial quantities in Alaska. In Washington and adjoining portions of British Columbia occur the only large deposits of limestone located on deep water along the entire Pacific Coast of the United States and Canada. Extension deposits occur in the northern tier of countries from Puget Sound to the Idaho boundary. These deposits constitute the sources for six Portland cement, one hydrated lime and numerous lime kiln plants now located within the State of Washington.

Clay deposits suitable for use in common brick manufacture are widely distributed throughout the Pacific Northwest, as are also those adapted to the manufacture of drain tile. In numerous places are also found deposits of clays which can be used for the manufacture of paving brick, sewer tile, terra cotta and firebrick. Both Washington and British Columbia are now producers of refractory brick of a high grade. Washington now ranks fifteenth in the production of clay products in the United States, forty-five firms being engaged in the industry and producing wares valued at over $2,000,000 annually.

Deposits of diatomaceous earth of superior quality have been investigated in five locations within the State of Washington. Apparently enormous quantities of this material exist in this State. Deposits of magnesium carbonate and other magnesium salts have been reported, but are not utilized. Among other raw materials available in the Pacific Northwest are iron ores suitable for mineral paints and perhaps for pig iron; talc for use as a filter in paper manufacture; silica for glass, and sand, lime, brick and large deposits of stone for structural purposes. Among the latter especial mention should be made of the Alaskan marble and of the granites and sandstones of Washington. At least three extension deposits of tufa rocks occur in Oregon and Washington.

THE OPPORTUNITIES OF THE PACIFIC NORTHWEST

The opportunities of the Pacific Northwest are to be found in the utilization and distribution of the resources heretofore recited. Less than 100,000 persons are now employed in manufacturing industries, which produce products valued at $400,000,000 in the States of Oregon and Washington. An inspection of the foodstuffs of the city of Seattle reveals what is typical of the entire Northwest. In this city of 300,000 population, during the past year 7207 cars of vegetables and fruit were shipped into the city. This is equivalent to a carload for every seven families. Of three million packages making up the total receipt, a million and a quarter came from outside the State of Washington.

Agriculture is a dormant, undeveloped industry. Less than 10 per cent of the agricultural land of Washington has been improved and is utilized for agriculture. More than 2,500,000 acres of logged-off land of agricultural character remain uncleared and idle. This is due chiefly to the high cost of clearing the land by the methods which are commonly in use. The farms which have been developed from the wilderness of débris left by the logger represent a monument of industry to those who have reclaimed them and made them factors of production. In eastern Washington the problem has been different. Instead of the jungle the desert must be overcome. Irrigation has transformed large areas into orchards and meadows of great beauty and wonderful productiveness. But even there, out of 2,000,000 acres of irrigable land not more than 25 per cent has thus far been reclaimed. In British Columbia the estimated acreage of tillable land is 253,000,000 acres, of which not more than 12 per cent is occupied, and only about one-fifth of that is under cultivation. The great need of the Pacific Northwest is settlement by colonists. Transportation is available, water and power are abundant, natural resources of unknown extent and character await development—in brief, the harvest is great, but the workers are few.

In the industries already established greater intensification and closer utilization are urgent. Fully as much timber as is manufactured into lumber is either wasted by burning or used in an uneconomic manner. As will be shown in papers presented before the convention, the fir slabs of the sawmills contain nearly as much tannin as the chestnut wood, which is the basis of the tannin extract industry of the United States. But no extract plant exists in the Northwest, and even tanneries have had hard struggles for existence in spite of the fact that great quantities of hides are readily available. Men have looked at our great forests and have seen nothing but lumber in them, and, following the line of least resistance, they have cut down these forests and manufactured a single product. In the fisheries industry the results have been largely similar. Mr. John N. Cobb,

editor of the *Pacific Fisherman*, calls attention to the neglected fishery resources of the Pacific Coast in an admirable paper presented before the first annual meeting of the Pacific Fisheries Society. In the 120,000 tons of salmon offal annually wasted are millions of pounds of salmon eggs. Siberia in 1913 prepared 500,000 lb. of salmon eggs as caviar, while 24,000 lb. were prepared upon the Pacific Coast of America in the same time. In Japan whale meat is of considerable economic importance as a food product. The whaling stations of the Pacific Coast ship certain portions to Japan, but by far the largest portion is either made into fertilizer or else wasted. Methods of processing whale meat so that it could be marketed as a food product should be worked out by the technical men of the fisheries industry whereby millions of pounds of meat might be added to our national supply annually.

These are random instances of the wasteful methods whereby our natural resources are being developed. A more complete study of existing conditions would simply tend to multiply the number of them. The Pacific Northwest needs to apply the methods of self-examination which have been so successfully applied to the industries and resources of the more congested sections of this and other countries. It needs a closer alignment with the technical thought and progress of the day. In a word, it needs, not capital, but captains of industry. With more care for the utility of natural resources and with the co-operation of the technical skill of the day, opportunities will spring from hidden places, and industries will multiply, and the Pacific Northwest will take its place in the moving streams of commerce and trade.

* * *

The following list comprises the names of those members which registered during the first day of the meeting, but it is not a complete list of the attendance:

W. H. Adolph, Tsinan, China; F. C. Atkinson, Indianapolis, Ind.; Edward Bartow, Urbana, Ill.; Stuart J. Bates, Pasadena, Cal.; J. H. Beal, Urbana, Ill.; R. C. Benner, Fremont, Ohio; J. E. Berkheimer, Tacoma, Wash.; Page R. Boyles, Salem, Ore.; C. M. Brewster, Pullman, Wash.; H. A. Bright, Washington, D. C.; C. A. Browne, New York City; H. W. Brubaker, Manhattan, Kan.; T. J. Bryan, Oak Park, Ill.; Miss M. G. Buckhous, Missoula, Mont.; G. H. Burrows, Burlington, Vt.; J. C. Butcher, Clackamas, Ore.; C. E. Coates, Baton Rouge, La.; Lillian Cohen, Minneapolis, Minn.; H. T. Corbett, Washington, D. C.; J. E. Darrah, Champaign, Ill.; J. A. Dawson, Vancouver, B. C., Canada; L. H. Duschak, San Francisco, Cal.; R. A. Dutcher, Corvallis, Ore.; R. C. Eccles, Brooklyn, N. Y.; John B. Ekeley, Boulder, Colo.; F. R. Eldred, Indianapolis, Ind.; H. C. Enders, New York City; Harry L. Fisher, New York City; Roy Fitch, Washington, D. C.; Fred Flanders, Boston, Mass.; Frans Franken, Chicago, Ill.; George B. Frankforter, Minneapolis, Minn.; Edw. C. Franklin, Palo Alto, Cal.; John Fulton, Corvallis, Ore.; A. N. Gadsby, Washington, D. C.; E. D. Goldsmith, Tacoma, Wash.; George Grindrod, Kent, Wash.; W. J. Hale, Ann Arbor, Mich.; E. D. Heinrich, Tacoma, Wash.; Charles H. Herty, Chapel Hill, N. C.; E. Hockett, Columbus, Ohio; W. B. Holmes, Fremont, Ohio; J. S. Jones, Moscow, Idaho; James Kendall, New York City; J. R. M. Klotz, New York City; W. A. Lenenberger, Tacoma, Wash.; W. L. Lewis, Evanston, Ill.; J. K. Long, Evanston, Ill.; S. K. Loy, Laramie, Wyo.; Paul S. MacMichael, Auburn, Wash.; R. S. McBride, Washington, D. C.; J. F. McGregory, Hamilton, N. Y.; D. McIntosh, Vancouver, B. C., Canada; E. J. Mead, Everett, Wash.; R. B. Moore, Denver, Colo.; Rokuro Nakaseko, Kyoto, Japan; Arthur C. Neish, New York City; W. A. Noyes, Urbana, Ill.; F. A. Olmsted, Oregon City, Ore.; J. C. Olsen, New York City; C. L. Parsons, Washington, D. C.; I. K. Phelps, Washington D. C.; R. W. Rea, Portland, Ore.; E. Emmet Reid, Baltimore, Md.; Clifford Richardson, New York City; W. D. Richardson, Chicago, Ill.; E. F. Roeber, New York City; C. F. Rudmann, Ironton, Ohio; Edward Schramm, Washington, D. C.; E. Schwerdtfeger, Seattle, Wash.; R. D. Smith, Hamilton, N. Y.; O. F. Stafford, Eugene, Ore.; Frank Sternberg, Victoria, B. C., Canada; J. K. Takenaka, Portland, Ore.; Herman V. Tartor, Corvallis, Ore.; A. D. Thorburn, Indianapolis, Ind.; Bailey Tremper, Auburn, Wash.; Paul Van Horst, Tacoma, Wash.; Carl L. von Ende, Moscow, Idaho; R. G. Waltenburg, Washington, D. C.; B. L. Wehmhoff, Bremerton, Wash.; F. A. Werts, Washington, D. C.; A. S. Wheeler, Chapel Hill, N. C.; H. H. Whiteside, Auburn, Wash.; A. M. Williamson, Niagara Falls, N. Y.; James R. Withrow, Columbus, Ohio; Frank Wright, Kent, Wash.; F. N. Yuill, Indianapolis, Ind.; Clarence Zischkan, Tacoma, Wash.; H. F. Zoller, Tacoma, Wash.

Oxy-benzyl-methyl-englycol-anhydride or "modern magic" is the title of a booklet issued by the General Bakelite Co. for distribution at the San Francisco Exposition. This booklet describes the various uses of Bakelite.

The Improvement of High Boiling Petroleum Oils, and the Manufacture of Gasoline as a By-Product Therefrom, by the Action of Aluminium Chloride[1]

BY A. M. MCAFEE

The conversion of high boiling petroleum oils into lower boiling oils of greater commercial value is an old problem, and many solutions of it have been proposed. Formerly, when kerosene was worth more than gasoline, naturally the effort was to increase the yield of kerosene from crude oil; nowadays, gasoline is worth more than kerosene, and naturally the effort is to increase the yield of gasoline. But in principle, gasoline making and kerosene making from high boiling petroleum oils are the same, and most of the proposed methods make both products. With very little variation, most of them will make gas equally well. A careful examination of these methods will show, in nearly all cases, the same principle, namely, what is called cracking—heating to a sufficient temperature to cause the high boiling oils to become unstable and break down into lower boiling oils. If the heat be intense enough and the time be long enough the product will be gas; a less heat and a shorter time will make gasoline, and a still less heat and shorter time will make kerosene.

Cracking Methods

The inventors have rung the permutations on this simple idea; they heat under pressure and they heat under vacuum; they heat in the presence of gases; they heat in the presence of catalysts; they heat in tubes and they heat in boilers, etc., etc. It is safe to say that in 99 per cent of the methods which have been proposed for converting high boiling oils into lower boiling oils, "cracking" by heat is involved. Sometimes it is disguised in ornate language; sometimes it lurks behind intricate apparatus, but it is always there.

The difficulty, however, with all these cracking methods is a difficulty in principle. In breaking down the complex, high boiling hydrocarbons into several simpler ones, there is not enough hydrogen to saturate these newly formed bodies, and unsaturated hydrocarbons must necessarily result unless hydrogen be added or carbon subtracted. Hydrogen is too expensive and difficult to add, and, though a part of the carbon is readily enough subtracted and deposited, this subtraction and deposition never goes far enough, although the stillman might not be readily convinced of this. These cracked products are in large part unsaturated, and they are not desirable commercially. They are foul smelling; they are yellow in color and become rapidly more yellow on standing; they deposit large amounts of carbon on ignition in a gas engine; they burn with a smoky flame; they contain resinous bodies which cause gumming in use or on standing, etc., etc. They can, of course, be refined somewhat with sulphuric acid, but there must be too much of the acid used and too much of the oil is lost to permit in practice any thorough treatment with acid.

Aside from the poor quality of the liquid products obtained, the operation of the cracking process is attended with great difficulty where uniform results are desired. There are many variables on which the obtaining of such results depends—temperature, time, pressure and catalytic action of the walls of the containing vessel. A change in either of these variables makes a change in the products obtained. Using the same appa-

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[1]A paper read before the Seventh Semi-Annual Meeting of the American Institute of Chemical Engineers, San Francisco, Cal., Aug. 25, 1915.

ratus, the same pressure, and consuming the same time, a difference of a comparatively few degrees of temperature in cracking operations makes marked differences in the yield and quality of liquid products.

In most of the cracking processes, pressure is employed. Sixty to 100 lb. is usual, and some have proposed much higher pressures. It is here that the greatest difficulty becomes manifest—the great danger to the operators and to the plant. There is always a deposition of hard (and flinty hard) coke on the inner walls of the heating element. Some who have had considerable experience in cracking oils have said that the coke is forced into combination with the iron making it brittle, and thus utterly unable to withstand the high temperature and pressure employed. At any rate, the deposition of the carbon occurs where the element is hottest, causing a local overheating at that point. Under such conditions the tensile strength of the steel becomes an unknown quantity—as likely as not it yields to the stress without any warning. Oil vapors of a temperature around 650 deg. Fahr. ignite spontaneously when they evolve from a still into the surrounding atmosphere. In cracking processes the temperature is 750 deg. to 850 deg. Fahr., and even higher, hence the manifest danger of cracking petroleum oils under such pressures.

Aluminium Chloride Process

When I took up the gasoline problem, some two and one-half years ago, I dismissed from consideration the idea of cracking oils. Up to this time, or since the Friedel and Crafts British patent, No. 4769 of 1877, there had been some degree of mild interest shown as regards the effect which aluminium chloride might have on petroleum oils, but no positive results had followed from this interest. It appeared to me that this reaction might have far more significance than was then apparent; I trust this paper may in a measure exemplify its significance.

I have found that with proper control of the vapors leaving the distilling system and entering the final condenser, and with sufficient time given the aluminium chloride, high boiling oils can be completely broken down into lower boiling oils, and no matter how unsaturated the high boiling hydrocarbons may be, the low boiling oils produced therefrom are sweet smelling, water white and saturated. The reaction gives little gas and only about the right amount of carbon to allow production of saturated products. The carbon is deposited not in the form of a hard baked-on carbon, but as a granular, coky mass, easily removed from the still.

But there are other products than gasoline that can be made from petroleum which are commercially worth while, although in our efforts to increase the supply of gasoline we have apparently forgotten this fact. If the market value of the various products which can be obtained from crude petroleum be plotted, it will be found that there is a peak at the low boiling end and another at the high boiling end. Gasoline is worth more than kerosene and kerosene is worth more than gas oil, while the products following gas oil, paraffin and lubricating oils are worth as much or more than the gasoline.

The problem before me, therefore, knowing the reactive power of aluminium chloride, was to apply it to crude petroleum so that good heavy oils could be obtained while at the same time converting the less valuable portions of the crude into gasoline. The solution of this problem is found in my patent.

In the practical operation of this process, crude petroleum of any kind is first distilled until the naturally occurring gasoline and kerosene, if there be any present, is distilled off. As you are probably aware, in many of our crude oils, and especially some of those from Texas, California and Mexico, there is substantially no gasoline present, and very little kerosene. But in any event, the crude is first heated to free it of any moisture which it may contain, since the oil must be perfectly dry before adding the aluminium chloride.

The next step is to add anhydrous aluminium chloride to the remaining residual oil, and then bring the mixture to boiling in the still. Boiling is usually around 500 deg. Fahr., and generally remains between 500 and 550 deg. Fahr. during the entire distillation, extending over a period of twenty-four to forty-eight hours. There is no need of employing extra pressure or vacuum or special apparatus; any still with a stirrer in it suffices.

Granted sufficient time for the aluminium chloride to get in its work, the success or failure of this process depends upon the proper control of the temperature at which the oil vapors are allowed to leave the distilling system to enter the final condenser. Between the still and the final condenser are placed two air-cooled condensers connected in series, which separate the low boiling oils from the high boiling oils, returning the latter together with any volatilized aluminium chloride to the still. For a 1000-bbl. still the air condensers which we are now using are drums of oval cross-section, 3 ft. x 6 ft. x 6 ft. high. In addition to the air condensers, a 3-ft. dome is attached to the top of the still which serves to return most of the volatilized aluminium chloride and its compounds. The operation is so controlled that the vapor is kept at the desired temperature, as indicated by a thermometer placed in the vapor line at the point of exit of vapor into the final or water-cooled condenser. The temperature at this point should not exceed 350 deg. Fahr., otherwise not only will heavy oils distil over, but the aluminium chloride (or its compounds with hydrocarbons) will enter the condenser and clog it up. Under the first named condition, the distillate obtained will be a mixture of gasoline, solvent oil and kerosene, which are afterward separated by fractional distillation. There products are all water white, sweet smelling, saturated and need no refining with sulphuric acid. In practice, no treatment is given them, except a washing with alkali, followed with water, to remove hydrogen sulphide. With proper back-trapping of high boiling oils into the still from the air-cooled condensers, and a temperature of 300 deg. Fahr. in the vapor line, the distillate obtained will be gasoline alone, which is ready for the market when washed with an alkaline solution.

I have spoken of the time which should be given the aluminium chloride for the accomplishment of the desired results. It is a mistake to assume that with a given amount of aluminium chloride and boiling it up with oil the desired results will be obtained. That is far from the truth. I do not wish to impose upon your patience by dismissing consideration of the mechanism of this reaction by simply saying it is catalytic. I am fairly well satisfied that it is one of association or combination in the liquid phase and dissociation in the vapor phase. It is well known that aluminium chloride exists in the solid and liquid states as Al_2Cl_6 and in the vapor state as $AlCl_3$. It is also well known with what avidity aluminium chloride in the solid or liquid state will combine with other salts to form double salts. The most common of these double salts is that of aluminium and sodium chloride, which, at one time, as you know, was the source of metallic aluminium (Castner process). Aluminium chloride probably combines with these high boiling complex hydrocarbons in much the same way as it combines with sodium chloride, and when the boiling temperature is reached these double com-

pounds become unstable, and dissociate into lower boiling hydrocarbons, which, under the temperature control imposed in the vapor line, leave the distilling system as fast as produced. Al_2Cl_6 is again formed, and is capable of combining further with other high boiling hydrocarbons remaining in the still, and free carbon is formed simultaneously. This view of the reaction here involved is confirmed, I believe, by the operating conditions mentioned heretofore as necessary for obtaining the desired results.

While the operation, using crude oil as the starting material, can be carried on to produce larger or smaller quantities of gasoline, in practice it is carried on so as to convert the gas oil fraction into low boiling hydrocarbons and leave most of the high boiling hydrocarbons, that is, the paraffins and lubricating oils. Accordingly, the operation is interrupted after a portion of the crude has been converted into low boiling products, and the high boiling oil remaining in the still is pumped off while hot and on cooling is worked up into the usual paraffin and lubricating products. The aluminium chloride remains in the still enmeshed in a mass of coke, and the methods of its recovery are found in my patents, which, if I may, I will refer to further on in this paper.

Results of Tests

As illustrative of the action of aluminium chloride on high boiling petroleum oils I shall give below results obtained on typical crudes. For the sake of convenience, the distillate obtained by distilling the crude before the addition of aluminium chloride will be termed "primary distillate," the oil remaining in the still being termed "primary residual oil"; the distillate obtained by distilling the primary residual oil with aluminium chloride will be termed "secondary distillate," and the oil remaining in the still "secondary residual oil." Fahrenheit temperature and Baumé gravity are used throughout. The distillation tests were made on 100 c.c. samples contained in standard Engler flasks connected to a 22-in. Liebig condenser. All flash points noted are in open cut tester. Viscosities noted are on the Saybolt universal viscosimeter at 100 deg. Fahr. W.W. and S.W. are abbreviations for water white and standard white respectively.

Texas crude of 20.8 gravity was distilled until free from moisture and until the naturally occurring gasoline and kerosene had been distilled over.

Yield	Per Cent Crude
Primary distillate	7.14
Primary residual oil	91.26
Loss	1.60
Total	100.00

Tests on Primary Distillate.

Gravity	36
Bromine No.	5.46

Distillation Over, Per Cent	260 Deg. F.
10	320
20	344
30	368
40	386
50	400
60	442
70	468
80	490
90	505
95	520

The primary distillate yielded on fractional distillation the following products:

	Per Cent Crude	Grav.	Color	Per Cent Sulphur	Bromine Number
Gasoline	0.303	58.0	W.W.	0.065	4.8
Gas naphtha	0.180	51.0	S.W.	0.103	3.1
W. W. kerosene	1.260	41.6	W.W.	0.071	..
S. W. kerosene	1.530	40.9	W.W.	0.133	..
Gas oil	3.791	31.2	.....	0.386	..
Loss	0.076	....	.....	.....	..
Total	7.140				

Tests on Primary Residual Oil

Gravity	19.8
Viscosity	302

Distillation Over, Per Cent	480 Deg. F.
10	530
20	566
30	600
40	656
50	680

To the primary residual oil was added 7½ per cent by weight of anhydrous aluminium chloride, and the mixture brought to boiling. The following observations were made during the course of the run:

Time.	Temperature of Still	Temperature of Vapor Line	Distillate, Per Cent Charge	Grav.	Distillation Test: Over Deg. F.	Per Cent Below 350 Deg. F.	Per Cent Below 450 Deg. F.	Dry Point
P. M.								
1.00	454	268	Showed up	....	...	..	..	...
1.30	479	290	2.86	55.9	110	68	80	490
1.45	488	300	2.86	55.2	110	69	84	490
2.15	495	302	2.86	54.4	110	66	80	490
2.45	504	290	2.86	54.1	110	66	81	490
3.15	508	290	2.86	53.5	110	65	80	490
4.15	518	340	2.86	53.7	110	65	80	490
4.45	523	340	2.86	53.7	110	65	83	490
6.00	525	340	2.86	53.5	105	60	82	490
7.00	530	344	2.86	53.3	100	58	81	490
8.30	530	340	2.86	53.5	100	58	81	490
10.30	542	340	2.86	53.2	100	60	83	490
A. M.								
1.00	547	320	2.86	52.6	100	60	83	490
4.00	547	300	2.86	52.4	100	60	83	490
6.30	552	290	2.86	52.8	100	58	83	495
10.00	551	305	2.86	50.6	100	58	83	500
P. M.								
1.00	557	302	8.57	49.7	100	55	85	510
	From back trap		1.39					

The operation was stopped at the end of twenty-four hours.

Yield	Per Cent Charge	Per Cent Crude
Secondary distillate	52.86	48.24
Secondary residual oil	31.14	28.42
Loss (gas and coke)	16.00	14.60
Total	100.00	91.26

Tests on Secondary Distillate

Gravity	51.1

Distillation Over, Per Cent	100 Deg. F.
10	174
20	228
30	265
40	294
50	324
60	357
70	388
80	428
90	475
95	500

The secondary distillate on fractional distillation yielded the following products:

	Per Cent Charge	Per Cent Crude
Gasoline	36.18	17.45
Gas naphtha	26.62	12.85
W. W. kerosene	2.65	1.28
S. W. kerosene	9.53	4.59
Solar oil	21.80	10.52
Loss	3.22	1.55
Total	100.00	48.24

The tests on the gasoline and the gas naphtha are as follows:

	Gasoline	Gas Naphtha
Color	W.W.	S.W.
Odor	Sweet	Sweet
Bromine No.	4.2	3.2
Dr. test	O.K.	O.K.
Heat test	4	3
Sulphur	0.056 %	0.054 %
Gravity	64.5	50.2

Distillation Over, Per Cent	117 Deg. F.	Gravity	215 Deg. F.	Gravity
10	160	82.1	240	57.0
20	170	79.0	246	55.0
30	179	75.3	253	54.1
40	190	70.9	260	52.8
50	208	66.0	270	51.3
60	222	61.8	280	50.2
70	239	57.7	293	49.1
80	261	64.2	306	47.5
90	293	50.4	332	45.4
98 Dry Point	339	....	350	....

The secondary residual oil obtained in the above process had the following tests, when freed of aluminium chloride:

Color	Red—green bloom
Flash	185 deg. F.
Fire	250
Viscosity	105

This residual oil was reduced with steam in order to make lubricating oil.

Yield	Per Cent Charge	Per Cent Crude
Gas oil	10.00	2.84
Lubricating oil	90.00	25.58
Total	100.00	28.42

Tests on Lubricating Oil

Color	Red—green bloom
Gravity	21.9
Flash	290
Viscosity	122

Summary of Yield of Products from Texas Crude by the Aluminium Chloride Process

	Per Cent Crude
Primary gasoline	0.30
Secondary gasoline	17.45
Primary gas naphtha	0.18
Secondary gas naphtha	12.85
Primary kerosenes	2.79
Secondary kerosenes	5.87
Gas oil	17.15
Lubricating oil	25.58
Total	82.17
Loss account distilling primary distillate	1.60
Loss account distilling with aluminium chloride	14.60
Loss account redistillation of primary distillate	0.08
Loss account redistillation of secondary distillate	1.55
Total	100.00

The following table compares the yield of products from Texas crude by the aluminium chloride process with the yield of products as obtained when the crude is distilled in the usual manner:

	Per Cent Crude, Aluminium Chloride Process	Per Cent Crude, Usual Process
Gasoline	17.75	Zero
Gas naphtha	13.03	0.10
Kerosenes	8.66	4.30
Gas oil	17.15	52.00
Lubricating oils	25.58	25.50
Asphaltic residual oil	....	12.00
Total	82.17	93.90
Loss	17.83	6.10
Total	100.00	100.00

In ordinary practice no gasoline is obtained from this type of Texas crude; by the aluminium chloride process 17.75 per cent is obtained and those who are familiar with the tests on petroleum products will see that this gasoline is as good as the natural gasoline made from any crude petroleum. The gas naphtha, which might very well be mixed with the gasoline, has been increased from 0.1 per cent to 13.03 per cent. It will be observed that these low boiling oils have been made at the expense of the gas oil fraction and the asphaltic residual oil, the latter being broken down completely. Gas oil is the least valuable constituent of the crude. The asphaltic residual oil is used for fuel or is made into asphalt. The yield of lubricating oil by the aluminium chloride process is about the same as that in the usual process, but the quality of the former is greatly improved by virture of the saturating effect of the aluminium chloride and the elimination of asphaltic and resinous constituents from the oil. I have samples here of these products that I shall be glad for any of you to examine.

It will not be necessary to go into so much detail with the remaining crudes of which I desire to speak, but I have wanted to give you these figures on Texas crude to show how regularly the reaction proceeds over a long period of time, what the physical characteristics of the products are, and the yield as compared with the usual process.

A Caddo (Louisiana) crude of 41 gravity was distilled to free it from moisture and natural gasoline:

Yield	Per Cent Crude
Primary distillate	26.19
Primary residual oil	71.43
Loss	2.38
Total	100.00

Tests on Primary Distillate

Gravity	58.2
Distillation Over, Per Cent,	160 Deg. F.
10	215
20	232
30	247
40	260
50	276
60	296
70	315
80	343
90	402
95	450
Dry point	500

The primary distillate on fractional distillation yielded:

Yield	Per Cent Charge	Per Cent Crude
Gasoline	82.00	21.48
Kerosene	15.00	3.93
Loss	3.00	0.78
Total	100.00	26.19

Five per cent by weight of aluminium chloride was added to the primary residual oil and the mixture brought to boiling. Distillation was continued for forty-eight hours, the temperature of the vapor line at the point of exit into the final condenser being held around 350 deg. Fahr.:

Yield	Per Cent Charge	Per Cent Crude
Secondary distillate	58.33	41.67
Secondary residual oil	26.20	18.71
Loss (gas and coke)	15.47	11.05
Total	100.00	71.43

Tests on Secondary Distillate

Gravity	54.0
Distillation Over, Per Cent	102 Deg. F.
10	212
20	260
30	293
40	315
50	340
60	365
70	388
80	414
90	450
95	480
98 Dry point	500

The secondard distillate on fractional distillation yielded the following products:

Yield	Per Cent Charge	Per Cent Crude
Gasoline	50.00	20.84
Solvent oil	40.00	16.67
Gas oil	6.00	2.50
Loss	4.00	1.66
Total	100.00	41.67

Following are the tests on the gasoline and solvent oil:

Color	W.W.	W.W.
Odor	Sweet	Sweet
Bromide No.	2	3
Dr. test	O.K.	O.K.
Heat test	2	2
Gravity	58.0	48.1
Distillation Over, Per Cent	120 Deg. F.	340 Deg. F.
10	198	354
20	221	360
30	240	364
40	258	369
50	272	374
60	288	381
70	301	390
80	322	400
90	348	416
95 Dry point	362	430
98 Dry point		440

Tests on Secondary Residual Oil

Color	Red—green bloom
Gravity	36.5
Flash	260 deg. F.
Fire	300
Pour	90 deg. F.

This residual oil was distilled until 30 per cent of the charge had been distilled over.

Yield	Per Cent Charge	Per Cent Crude
Gas oil	30.00	5.61
Paraffin residual oil	70.00	13.10
Total	100.00	18.71

Tests on Paraffin Residual Oil

Color	Amber
Pour	105 deg. F.
Flash	375
Fire	420

Summary of Yield of Products from Caddo (Louisiana) Crude Oil by the Aluminium Chloride Process

	Per Cent Crude
Primary gasoline	21.48
Secondary gasoline	20.84
Secondary solvent oil	16.67
Primary kerosene	3.93
Gas oil	8.11
Paraffin residual oil	13.10
Total	84.13
Loss account aluminium chloride distillation	12.71
Loss account working distillates into standard products	3.16
Total	100.00

The following table compares the yield of products from Caddo crude by the aluminium chloride process and the yield of products as obtained in usual practice.

	Per Cent Crude Al_2Cl_6 Process	Per Cent Crude Usual Process
Gasoline	42.32	18.00
Solvent oil	16.67	12.00
Kerosene	3.93	35.00
Gas oil	8.11	21.00
Paraffin residual oil	13.10	11.00
Total	84.13	97.00
Loss	15.87	3.00
Total	100.00	100.00

This crude belongs to the same type as Pennsylvania crude—the type known as paraffin base crude. Their products are clean smelling and require but little acid in refining. But even this type of crude is considerably improved by the aluminium chloride process, while at the same time the yield of gasoline is greatly increased. The paraffin residual oil from Caddo crude is black and tarry on account of the presence of asphaltic constituents, but these are not usually present in large enough amounts to prevent the manufacture of good paraffin and paraffin lubricating oil. The distillation with aluminium chloride destroys the asphaltic constituents, giving an amber colored residual oil which may be easily worked into a product, commercially known as vaseline, or into paraffin and paraffin lubricating oils. At the same time the yield of gasoline from the crude is increased from 18 per cent to 42.32 per cent.

An Oklahoma crude of 34 gravity was distilled to free it from moisture and natural gasoline.

Yield	Per Cent Crude
Primary distillate	20.83
Primary residual oil	78.31
Loss	0.86
Total	100.00

Tests on Primary Distillate

Gravity	54.1
Color	W.W.

Distillation Over, Per Cent	152 Deg. F.
10	210
20	226
30	242
40	252
50	271
60	290
70	313
80	345
90	408
95 dry point	455

This primary distillate on fractional distillation yielded the following:

Yield	Per Cent Charge	Per Cent Crude
Gasoline	70.00	14.58
Kerosene	20.00	4.17
Gas oil	7.50	1.56
Loss	2.50	0.52
Total	100.00	20.83

Tests on Primary Residual Oil

Color	Black
Gravity	29.8
Flash	170
Fire	205
Pour	20

Distillation Over, Per Cent	330 Deg. F.
10	436
20	484
30	543
40	590
Below 600 deg. F	43 per cent

To the primary residual oil was added 5 per cent by weight of aluminium chloride. Distillation was then continued for a period of 48 hours; the temperature of the vapor line at the point of exit into the final condenser being held around 350 F.

	Per Cent Charge	Per Cent Crude
Secondary distillate	64.61	50.60
Secondary residual oil	17.97	14.07
Loss	17.42	13.64
Total	100.00	78.31

Tests on Secondary distillate

Gravity	48.3

Distillation Over, Per Cent	140 Deg. F.
10	225
20	270
30	294
40	326
50	358
60	382
70	413
80	454
90	503
95	547
98 Dry point	570

On fractional distillation this secondary distillate yielded the following:

Yield	Per Cent Charge	Per Cent Crude
Gasoline	40.00	20.24
Kerosene	50.00	25.30
Gas oil	7.50	3.80
Loss	2.50	1.26
Total	100.00	50.60

Tests on gasoline:

Color	W.W.
Odor	Sweet
Bromine No.	1.5
Dr. test	O.K.
Heat test	2
Sulphur	.027%
Gravity	64.5

Distillation Over, Per Cent	130 Deg. F.	Gravity
10	160	83.8
20	186	76.2
30	200	70.1
40	213	66.6
50	222	62.8
60	238	60.4
70	252	58.5
80	270	56.1
90	299	53.3
Residue	8.3%	48.2

Tests on Secondary Residual Oil

Color	Red—green bloom
Gravity	28.2
Pour	90 deg. F.
Flash	230 deg. F.

This secondary residual oil was distilled to produce wax stock and cylinder oil.

Yield	Per Cent Charge	Per Cent Crude
Wax stock	60.00	8.44
Cylinder oil	40.00	5.63
Total	100.00	14.07

Summary of Yield of Products from Oklahoma Crude by the Aluminium Chloride Process

	Per Cent Crude
Primary gasoline	14.58
Secondary gasoline	20.24
Primary kerosene	4.17
Secondary kerosene	25.30
Gas oil	5.36
Residual oil	14.07
Total	83.72
Loss account aluminium chloride distillation	13.64
Loss account working distillate into standard products	2.64
Total	100.00

The following table compares the yield of products from Oklahoma crude by the aluminium chloride pro-

cess and the yield of products as obtained in usual practice.

	Per Cent Crude Aluminum Chloride Process	Per Cent Crude Usual Process
Gasoline	34.82	12.50
Kerosene	29.47	41.00
Gas oil	5.36	35.00
Residual oil	14.07	9.00
	83.72	97.50
Loss	16.28	2.50
Total	100.00	100.00

The residual oil from this crude by the usual process is a black, tarry mass, containing large amount of asphaltic constituents and also paraffin. The amount of asphaltic constituents is so great, as a rule, that it is difficult to make paraffin and paraffin lubricating oils of the same grade as that obtained from Pennsylvania or Caddo residuums. By the aluminium chloride process this residual oil is cleaned of its asphaltic constituents, and paraffin wax and paraffin lubricating oils of excellent quality are made therefrom. At the same time, the yield of gasoline from the crude is greatly increased, at the expense of the less valuable fractions of the crude.

Although the crude petroleums from the various oil producing districts in this country differ greatly in quality and in chemical composition, yet they are generally divided into three types: Asphaltic-base crude, paraffin-base crude, and paraffin-asphaltic-base crude. The oils I have spoken of in this paper are representative of each of these types; Texas, asphaltic-base crude, Caddo, paraffin-base crude, and Oklahoma, paraffin-asphaltic-base crudes. To give figures on other crudes would be merely a repetition of the results obtained on one of these. I shall therefore not take the time to give further examples. I might add that among the samples here are products made by the aluminium chloride process from 14 gravity California crude and 20 gravity Mexican crude.

Recovery of Aluminium Chloride

But all the good results of this process would be of no commercial value if the aluminium chloride could not be reclaimed. This chemical when made on the ton scale is not so expensive as it is when made on the pound scale, but nevertheless its cost is high, and from a dollars and cents point of view, it is necessary to recover it. And this is done by the processes set forth in my patents.

After a time, 48 hr. or longer, aluminium chloride used in distilling oils, even the driest of oils, loses its catalytic activity and becomes converted into a coky mass. Analysis of the coky mass shows chlorine and aluminium present in the right proportions to form aluminium chloride, but the latter is, so to speak, masked. It does not display its ordinary reaction with petroleum hydrocarbons. The granular coky residue after it comes from the oil converting process, carries varying amounts of oils with it. If allowed to cool down in the presence of the body of oil, it may carry 40 to 50 per cent of its weight of oil. If the oil body has been separated while hot from the coky residue, the amount of oil will be reduced to 4 or 5 per cent.

After removing the oil, or the bulk of it, from the coky residue, the aluminium chloride can be extracted from the latter with water or steam to obtain a concentrated solution of hydrated aluminium chloride. Aluminium chloride in the hydrated state does not have the catalytic property of the anhydrous material, but the hydrated salt can be used as the raw material for making the anhydrous salt. To do this, advantage is taken of the property of hydrated aluminium chloride breaking up when moderately heated to form aluminium oxide and hydrochloric acid gas. The alumina when mixed with carbon and treated with hydrochloric acid vapors at a high temperature, react to form the anhydrous chloride, hydrogen and oxides of carbon. In utilizing this property, one portion of the hydrated chloride is heated to produce hydrochloric acid vapors and alumina, and these vapors on drying enter a further charge of alumina and carbon heated to redness. The hydrochloric acid vapors given off at a moderate temperature are thus utilized in further operations at high temperatures.

In another method of recovery, and the preferred one, the coky residue is heated to red heat in an atmosphere of chlorine which disengages the aluminium chloride from the carbon. Aluminium chloride volatilizes normally at a temperature around 365 deg. Fahr., but the coky residue may be heated to redness without much evolution of these vapors. If the heating is done in an atmosphere of chlorine the aluminium chloride is unlocked, so to speak, and vaporizes away from the carbon, and is condensed in suitable receivers.

Of course, the last and ultimate test of any process is whether it will work, and work successfully without undue petting. That the aluminium chloride process is now an assured commercial success, is, of course, due to its own merits. But I cannot forego this opportunity to speak of the generous aid from the Gulf Refining Company, which has made success possible, and the valuable advice and help from its officers.

Although this account by no means covers the full scope of the aluminium chloride reaction with petroleum oils, yet to speak further would lead me outside of my subject.

The New Mill of the Daly West Mining Co., Park City, Utah

BY L. O. HOWARD

The destruction by fire, in December, 1913, of the mill and shaft house of the Daly West Mining Co. at Park City, Utah, gave the company an opportunity to simplify its practice. The old plant was characterized by all the complications and repeated retreatments, a multiplicity of screens and classifiers, endless succession of middling tables, etc., that the practice of a decade ago favored in the concentration of lead and zinc ores.

The old mill was of the hillside type, and in the same structure as the shaft- and boiler-house. This resulted in the total destruction of the surface plant when fire started in a portion of the works.

The ore of the Daly West mine is a sulphide of lead and zinc, with some copper, and about 3 oz. of silver for each per cent of lead, in a gangue of limestone and quartzite. It is mined to a depth of 2100 ft. through a two-compartment shaft. First-class ore, assaying about 18 per cent lead, 9 per cent zinc, 2 per cent copper, 52 oz. of silver, and 0.04 oz. of gold, is sorted out underground, hoisted to the 1200-ft. level, and hauled 2½ miles through the Ontario drain tunnel to Park City, near the site of the old Ontario mill. Second-class ore is hoisted to the surface. For some years this ore has assayed about 5 to 6 per cent lead, 5 to 6 per cent zinc, and 7 to 8 oz. silver.

THE OLD MILL

Preceding the description of present practice and for purposes of comparison, a brief outline of previous practice may be of interest. All ore was hoisted in cars on two three-deck cages and dumped over eight grizzlies into sixteen separate coarse and fine-ore bins, from which it was taken by belt conveyor to a Gates crusher set to 1 in. From the 1.5-in. oversize of the grizzlies, waste and first-class ore was sorted out.

Second-class ore was delivered to the mill bins. After sampling it dropped to the first set of rolls, then to the limiting trommel, where all ore over three-mesh was sent to finishing rolls, then to another three-mesh trommel. The oversize of this trommel was delivered to a two-mesh scalping trommel, which returned its oversize to the finishing rolls. The undersize from both three-mesh trommels was delivered to a series of trommels having screens of four-mesh, six-mesh and eight-mesh cloth. The respective oversizes were sent to four sets of two two-compartment Harz jigs each. Concentrate was taken off the four coarse jigs through the hutches and side-draw gates. The fine jigs made only hutch product and tailing.

Coarse tailing, after dewatering, was reground in three Sherman mills, which were modifications of the Huntington mill.

Following the last trommel came the first tanks of the classification system. The old mill had no hydraulic classifiers, but used a system of tanks and classifiers devised by the mill superintendent and known as Sherman tanks and Sherman classifiers. The latter were of special interest. They were cylindrical with conical bottoms, and set in series with a progressive increase in diameter and decrease in height. Fig. 1 shows some of these tanks in the ruins of the old mill. In the main

FIG. 1—A PORTION OF THE OLD DALY WEST MILL, SHOWING ARRANGEMENT OF SHERMAN CLASSIFIERS. NEW SHAFT-HOUSE AND HEAD FRAME IN BACKGROUND

mill the diameters were 4, 6, 8, 10 and 12 ft. Pulp was fed through a central cylinder, of one half the cross-sectional area of the outside cylinder, and the overflow passed upward between the two cylinders and into a launder at the periphery of the larger cylinder. From the spigots were drawn the feeds for the various concentrating machines.

From the first tanks another set of fine jigs was fed, which made a finished hutch, the tailing joining the reground tailing from the coarse jigs. This tailing went to the next two Sherman tanks, feeding six Wilfley tables, which made four products; concentrate to smelter, tailing, slime, and middling, which was sent to three more Wilfleys, which made similar products to the first, the middling from these being passed over two more Wilfleys.

The slime from the first Wilfleys, and the overflows from the various Sherman tanks, went to a set of five Sherman classifiers. Tailing from the three sets of Wilfleys and slime from the last two sets were passed over an eight-mesh screen, the undersize going to other Sherman classifiers in a separate structure, known as Mill No. 2, the oversize going to Mill No. 3.

The five Sherman classifiers in Mill No. 1, receiving the coarser overflows from the Sherman tanks, and some returns from later parts of the system, fed three Wilfley tables and two Sherman slime tables, which were similar to the old tray-type of Wilfley table. All these tables made finished concentrate, sent tailing to Mill No. 2 and returned middling to the five classifiers. The overflow of the last of these classifiers was further settled in a long tank, which fed two more Sherman slime tables, which made a finished concentrate and sent tailing to the tailing plant, Mill No. 2.

The Old Tailing Mill

Mill No. 2 was characterized by a long-extended series of tanks and classifiers of the Sherman type. Tailing was received in a 6 x 6 tank, the spigot product from which was screened over 8-mesh, undersize being treated, after passing through another small tank, on a 2-compartment Harz jig, where a finished concentrate was made, tailing going to No. 3 Mill. Oversize of 8-mesh was reground in a Sherman mill and sent to six Sherman classifiers, along with the overflow from the tanks. These tanks varied in diameter as follows: 3 ft., 4.5 ft., 5.5 ft., 7.5 ft., 10.5 ft. and 14 ft.

This set of classifiers fed three Wilfley tables and three Overstrom tables, all of which returned middling and slime to the classifier, made finished concentrate and sent tailing to mill No. 3.

The overflow from the classifiers was further settled in eighteen 6 x 6 tanks, which fed one slime table, making finished concentrate, middling to be returned to classifiers, and tailing to Mill No. 3. The final overflow from the eighteen tanks was used as wash water on the tables in Mill 2, not without further settling, however.

Mill No. 3

Mill No. 3 was simple. Here the incoming tailing was received in a settler, the material which settled being discarded (the first discard from the plant) and the overflow again settled. The spigot of the second settling tank discharged to an eighty-mesh screen, which rejected the oversize and fed the undersize to four slime tables, which also received the overflow of the second settler, after it had been further thickened in two more tanks. These slime tables made finished concentrate and tailing and returned middling to the second settler.

At a later time there was added a trommel and two more jigs to treat further the coarse material.

The writer has given the above description with some hope, but not too much expectation, that the reader will be able to visualize the practice. At least it will serve to emphasize the complication of the old plant and serve as a measure of the simplification attained in the new plant.

According to the report of the mill superintendent for 1913, the old plant treated 190 tons per 8-hr. shift, with an extraction of 99.6 per cent of the lead, 22 per cent of the zinc and 79.55 per cent of the silver. The high lead extraction is due to the custom of figuring the lead in zinc concentrate as part of the extraction. The mill treated 59,233 tons of ore assaying 5 per cent lead, 7.7 oz. of silver and 4.3 per cent of zinc, producing 8332 tons of lead concentrate assaying 34.54 per cent lead, 40.01 ounces silver and 1598 tons of zinc concentrate assaying 35.37 per cent zinc, 4.83 per cent lead and 19.27 oz. of silver. These figures would indicate an extraction of 97 per cent of the lead. It is not stated how the weight of crude ore was determined or how the sample was taken, so that the reason for this apparently high recovery is not evident.

The mill was driven electrically, power being generated by boilers, 300 horsepower being required.

The mill force consisted of twenty men per shift.

The illustrations of the present mill—Figs. 2, 3 and 4—show that much less floor space is required, and precaution has been taken to have the shaft-house, crusher-house and mill widely separated.

The New Mill Structures

The new mill, which went into commission in January of this year is housed in two structures, one 71 ft. long, 27 ft. wide and 60 ft. high from floor line to top of ore bins, housing the storage bins and the primary crushers. The main mill building has the approximate dimensions shown in the sketch, Fig. 5. The crusher-house is of frame construction, as is the mill proper, the latter being covered with corrugated iron. The

FIG. 2—VIEW OF DALY WEST MILL, LOOKING WEST

mill is of the hillside type, the fall from the head of the mill proper to the tailing launders in the tunnel beneath the mill being about 70 feet.

There are five levels. At the top are the receiving bins. On the floor below, the fourth, are two Franz jigs, above which are the feeding trommel and Akins classifier. On the third floor are the roughing Wilfleys, Harz jigs, Sherman tanks and regrinding rolls. On the second floor are eight concentrating tables and the flotation plant, and on the first, the Harz tailing jig and concentrate launders.

The accompanying flow sheet shows the greater simplicity of the new plant. The ore is hoisted in two 4-ton skips and dumped into bins in the head-frame, waste being dumped into its own bin and trammed to the dump.

The seoond-class ore is drawn on to an 18-inch belt conveyor, 270 ft. long, which delivers the ore to the bins at the top of the ore-house, at an elevation 12 ft. lower. The ore is received in two bins, 12 ft. x 12 ft. in cross-section, and 35 ft. deep, holding 600 tons or enough for three days' run. From the bins the ore is fed by 30-in. Stephens-Adamson belt feeders, adjustable to three speeds, over 3-ft. x 6-ft. grizzlies, having a 45-deg. slope, with 2-in. spacing of the bars, which are of cast iron, 3 in. deep, ¾ in. wide at the top and ¼ in. wide at the bottom.

Magnetic Removal of Steel from Feed

A 10-in. x 20-in. Blake crusher, made by the Colorado Iron Works, takes the oversize and discharges to a trommel, which is 48 in. by 72 in., and is covered with double-crimped wire screen, having two meshes to the inch. A 24-in. belt conveyor, 12 ft. long, takes the oversize of the trommel to a 48-in. Symons disc crusher. The head pulley of this conveyor is magnetized to remove all pieces of steel from the feed.

In operating the Symons crusher there has been at intervals some trouble due to choking which has been gradually overcome. Points of steel, 6 to 8 in. long, have gone into the crusher without other effect than to blow the fuses. Since the mill was started the crusher has given generally good results, but after six months' service further trouble was had due to the discs becoming wedged with babbitt, stripping the driving gears and interfering with the operation of the mill until new parts could be obtained from the manufacturer. At the time of the writer's visit the mill was crippled from this cause, so that the best work of the newer equipment could not be seen.

The discharge of the Symons crusher and the undersize from the trommel are taken from the ore-house to the mill bins by a 24-in. Robins belt conveyor, 210 ft. long, up a 6-deg. slope. Midway of the belt travel is a Blake-Denison weigher, having a capacity of 30 tons per hour.

Franz Jig Removes the First Concentrate

The ore is sampled as it falls into the bin by a box rotating on a vertical axis at the rate of one revolution in 10 minutes. After the cut has been made the box travels a half revolution, to a point where its front end comes in contact with an inclined rail which tilts the box so that it discharges through the back end to the sample chute.

From the bin the ore is fed into a 48-in. by 72-in. trommel, covered with a two-mesh screen of double-crimped wire cloth. The oversize goes directly to one of two Franz jigs, the undersize going to the other after the slime has been removed in a 51-in, Akins classifier.

These jigs are of the movable screen type and are more often seen in the Missouri zinc districts than in the West. The screens are 10 ft. long and 27 in. wide. On the coarse jig the screen size is changed at intervals, the first two feet having 5/16-in. apertures, the next three feet having ½-in. apertures and the remainder being divided between screens having apertures of ⅝-in. and ¾-in. respectively. The fine jig has 2½ ft. each of the following sizes: 3/16-in., ¼-in., 5/16-in., ⅜-in. Screens are of plate punched with round holes. Both jigs are run at 240 revolutions per minute, the fine jig having a stroke of ¾ in. and the coarse of 1 in. to 1¼ in.

The feed is divided in the proportion of 120 tons per

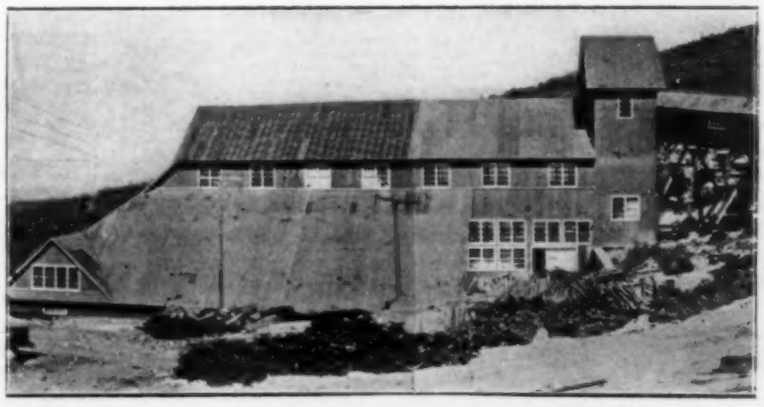


FIG. 3—VIEW OF DALY WEST MILL, LOOKING EAST

day to the coarse and 80 tons to the fine. The coarse jig makes three finished hutch products averaging 30 per cent lead, which go to the lead concentrate bins. The first two hutches of the fine jig are also finished products and will average about 35 per cent lead. The third hutch of the fine jig goes to two Wilfleys, which make a finished zinc concentrate and a tailing, which is retreated on the Harz jig on the lowest level of the mill.

Rolls Used for Regrinding

The tailing from the coarse jig is reground in 14-in. x 36-in. rolls, instead of Sherman mills, as in the old plant, and is elevated to a series of two sets of three Colorado Iron Works impact screens, where three sizes are made: on four-mesh, through four-mesh on eight-mesh, and through eight-mesh. The coarse is returned to the rolls. The middle size is treated on two three-compartment Harz jigs, which make two finished hutch concentrate products, and a third hutch and tailing, which are retreated on the same Wilfleys that receive the third hutch product of the fine Franz jig.

The undersize joins the slime from the Akins classifier and from the later table treatment, and is classified in a 5-spigot Richards-Janney classifier. Each spigot

FIG. 4—DALY WEST CRUSHER HOUSE WITH CONVEYOR SHEDS. MILL ON RIGHT. ASSAY OFFICE IN LEFT CENTER FOREGROUND

feeds two Wilfley tables, the oversize, after thickening, going to the flotation plant. Contrast this simple separation of sizes with the complicated mechanism of the old plant.

Fine Concentration on Wilfley Tables

The ten Wilfleys make similar products, a finished lead, concentrate, tailing, and middling, which is retreated for a finished zinc concentrate and a tailing on three Wilfleys, and head water, which is returned to the classifier.

The concentrates from the Harz jigs and Wilfley tables drop to separate lead and zinc launders suspended on hangers and running across the width of the mill in a tunnel on the lowest level. The head end of the launders is connected to a shaking device which causes the concentrate to flow forward to two sets of two elevators in series, which discharge into two Akins dewaterers, the drained concentrates dropping into lead and zinc bins. They are then trammed in one-ton cars through a tunnel to a sub-level of the ore-house, and are then elevated on a cage to the conveyor shed connecting shaft and ore-house, and trammed to the shaft. They are then lowered to the 1200-ft. level and hauled out through the Ontario tunnel to Park City, where they are loaded on wagons and hauled to the sampling works, a short distance below the city.

All the tailing from the concentrating department goes to a two-compartment Harz jig, on the lowest level, the hutch products being returned to the circuit ahead of the impact screens.

The tailing from this jig is sampled by a tilting box sampler before running into the tail race.

Flotation Department

The feed to the flotation plant consists of slime from the Richards-Janney classifier, which is thickened in one large and 23 small settling tanks of the type used in the old mill. The unit consists of two mixing cells and fourteen flotation cells, having a capacity of thirty tons of dry slime per day. The type is similar to that used by the Federal Lead Company. Each cell is 4 ft. 4 in. long by 20 in. wide and 5 ft. 8 in. deep at the tailing discharge end. They are set side by side, with their sides in common. The illustration, Fig. 7, shows an end view, and the shape of the cells is further illustrated diagramatically in the approximate sketch, Fig. 8.

The slime is fed into the first mixing chamber, where it is mechanically agitated by a vertical propeller driven by belt from a line shaft extending the length of the unit. From this compartment it is drawn into a second similar one and then into a third, which is part of the first flotation cell. Each flotation cell has two compartments, one similar to the mixing cells and another longer one, where the flotation is effected. A flotation concentrate is taken off each cell, the tailing passing through the whole system of cells in series.

The propeller in one cell draws the tailing from the bottom of the preceding flotation compartment and discharges through a slot at the top into its own flotation comparament. The froth floats to the opposite end of the flotation compartment and is skimmed off by a

FIG. 5—PLAN OF DALY WEST MILL, APPROXIMATE DIMENSIONS AND SCALE

paddle wheel which drops it into the concentrate launder, where a jet of water breaks the froth. The concentrate flows to a centrifugal pump which lifts it to an elevator delivering to the concentrate bins. This concentrate is marketed as a lead product.

The tailing settles to the bottom edge of the flotation compartment and is drawn into the next cell and again subjected to flotation, until it has passed the final cell, when it goes to the tail race. Flotation tailing is sampled by dipper. The weight of material treated is ascertained by specific gravity determinations made on a large sample caught during a definite period. I am unable to give analyses of concentrate and tailing, which would undoubtedly be instructive, if the management would release them.

Pine oil is introduced drop by drop into the first mixing cell. The consumption of oil is stated to be about 50 gal. per month, which is equivalent to about 0.4 lb. per ton of slime treated.

Miscellaneous Operating Details

The mill is operated one 8-hr. shift daily, with a force of fifteen men, and treats 200 tons per shift. Operations are controlled by means of the data obtained at the following points: The weight of ore fed to the mill is obtained from the Blake-Denison weigher, and the analysis of feed is made on the sample taken at

the end of the conveyor belt which brings the crushed ore to the mill from the crusher or ore-house; weight of concentrate is known and analyses are made on samples taken by pipe sampler from each car as it is taken from the concentrate bin; analyses of tailing are made on the sample taken by tilting box sampler from the

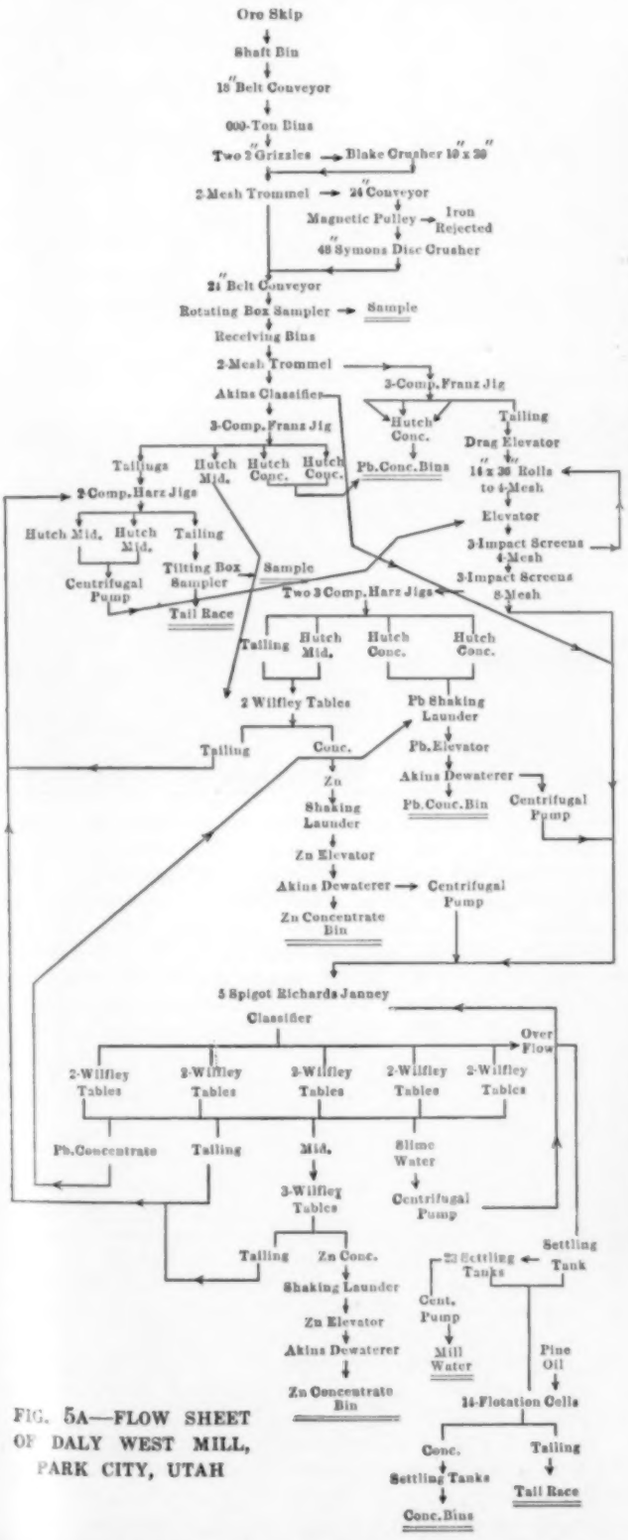


FIG. 5A—FLOW SHEET OF DALY WEST MILL, PARK CITY, UTAH

discharge of the tailing jig; the tailing from the flotation department, which does not go to the tailing jig, is sampled by dipper and the weight obained by specific gravity determinations made on pulp discharged for a known period. Regular samples are not taken during the course of the ore through the mill, but in case of any irregularity in the general tailing assay the suspected machines are subjected to a check sampling in order to remedy the trouble. As a result of this practice, I am unable to give figures on the work of individual machines, or on the grade of concentrate produced at different stages, or to give any information on the specific efficiency of different sections of the plant.

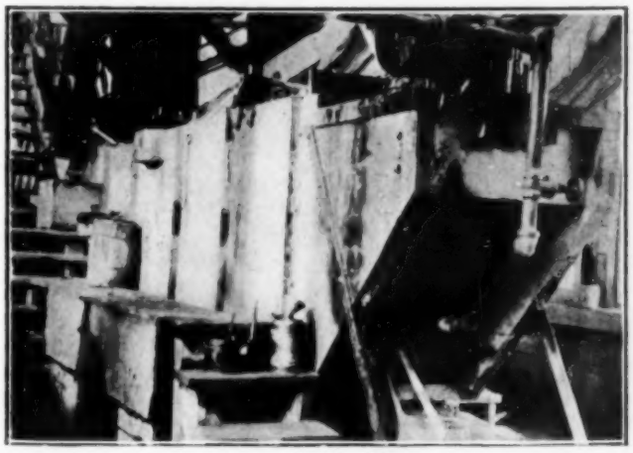


FIG. 6—FRANZ JIG IN DALY WEST MILL

Much of the equipment used in the new mill was salvaged from the ruins of the old. Head pulleys and belting for some of the elevators, classifier tanks, concentrating tables, shafting, conveying idlers, and some of the motors came from this source.

All tables now in use are the No. 5 Wilfleys, three Overstrom tables being held in reserve. The riffling is the No. 10 type, every other riffle being cut off a few inches short. In addition the so-called Thompson type

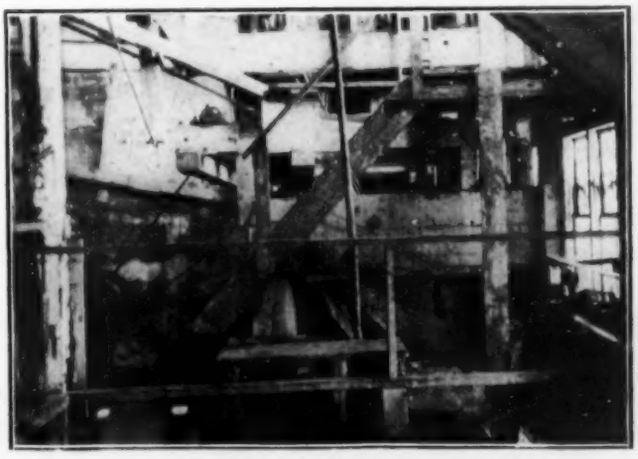


FIG. 7—FLOTATION CELLS, DALY WEST MILL

of riffle has been added. The alternate long riffles, which would ordinarily terminate in the well-known Wilfley diagonal, are extended a few inches upward toward the feed side of the table and then brought out parallel to the table to a second diagonal line. At other plants this type is said to have led to greatly increased capacity. Detailed figures as to results in the Daly West mill are not obtainable, although an average may be estimated by the reader.

Cleaning water is applied to the tables through perforations on the upper side of a two-inch pipe; this arrangement is shown clearly in the illustration of the lower table floor, Fig. 9. Water is brought from below

the floor to the tables, thus doing away with the overhead water pipes, and their attendant troubles.

The analysis of the metallurgical results of operation cannot be given until the publication of the annual report of the company for 1915, for the policy

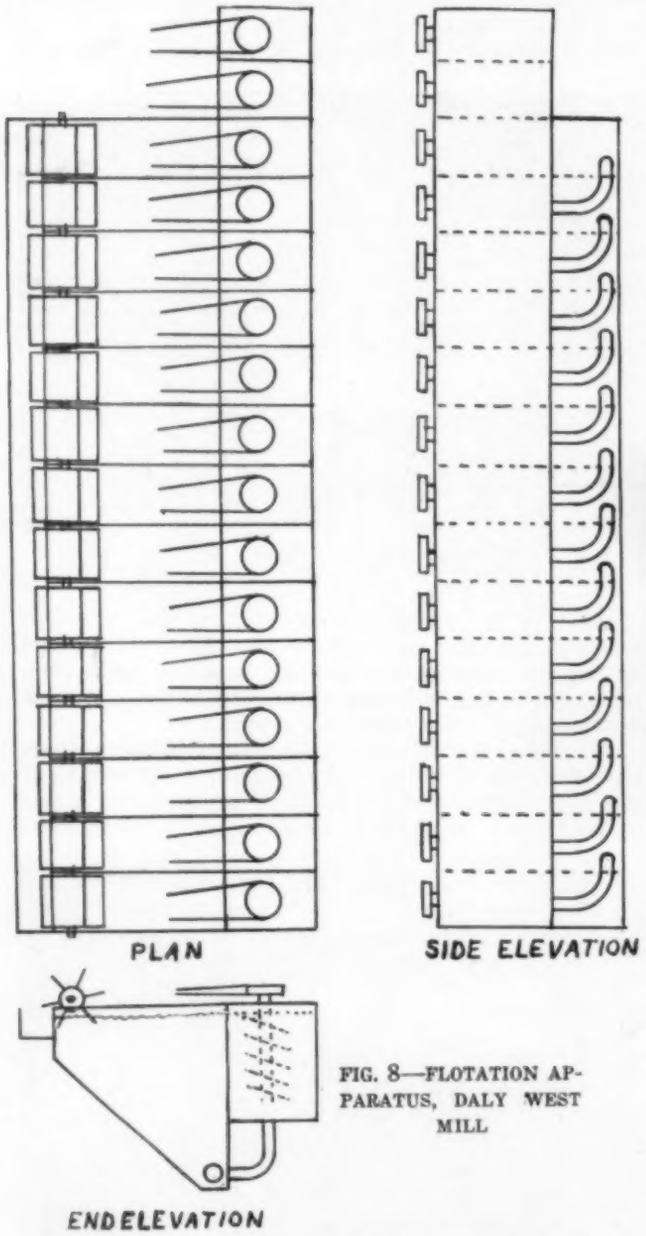


FIG. 8—FLOTATION APPARATUS, DALY WEST MILL

of the company has always been to give out but little information except through this source. However, a comparison of equipment used in this and the old mill may be of interest. Table 1 shows a list of the more important equipment in the old and the new plant side by side.

It will be noted that preliminary crushing and screening and regrinding units have been greatly decreased, as have the number and complications of the jigs. The number of elevators has been increased, but the load on them is diminished, as four of the elevators are for concentrates.

The compact flotation system has replaced the complicated classification and retreatment of slimes and has done away with the twelve slime tables. There still remain a large number of dewatering tanks preceding the flotation plant, used to thicken the feed to it. It would be interesting to know what a Dorr thickener would do if substituted for these numerous tanks. Of

TABLE I.

Equipment	Old Mill		New Mill	
Grizzlies	8	7 ft. long...	2	6 ft. long
	1	4.5 ft. long..		
Crushers	1	No. 4 Gates.	1	10 x 20 Blake
	1	10x20 Blake	1	48-in. Symons
	2	14x36 Rolls.		
Elevators	4	.....	5	
Screens	13	.....	8	
Jigs	12	2-comp. Harz	2	3-comp. Franz
			1	2-comp. Harz
			2	3-comp. Harz
			2	3-comp. Harz (Reserve)
Regrinders	4	Sherman ...	1	14 x 36 Rolls
Settling tanks	11	.....	25	
Classifiers	29	Sherman ..	3	Akins
			1	5-spig. Richards-Janney
Wilfley tables	14	.....	15	
Slime tables	12	.....	0	
Overstrom tables	3	.....	3	In Reserve
Flotation plant	0	.....	14	Cells
Tonnage per 8 hrs.	190	.....	200	
Men employed	20	.....	15	

course they have the advantage of absolutely no cost of operation, little maintenance and cheap first cost, in this instance being already on hand. The chief disadvantage is the large floor area required for them. I do not know their efficiency, but assume that they do satisfactory work.

Hydraulic classification in the form of one Richards-

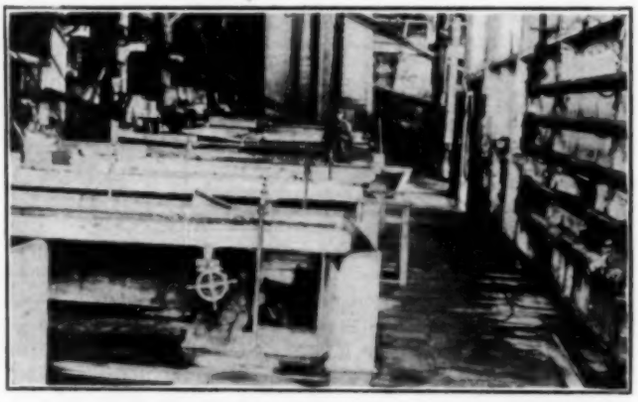


FIG. 9—LOWER TABLE FLOOR, DALY WEST MILL

Janney classifier has taken the place of numerous tanks in preparing the feed for the fine concentrating machines.

Milling water is obtained from lakes 1000 ft. above the mill and 3 miles south, being stored for mill use in large wooden tanks on the hill above the plant.

Power

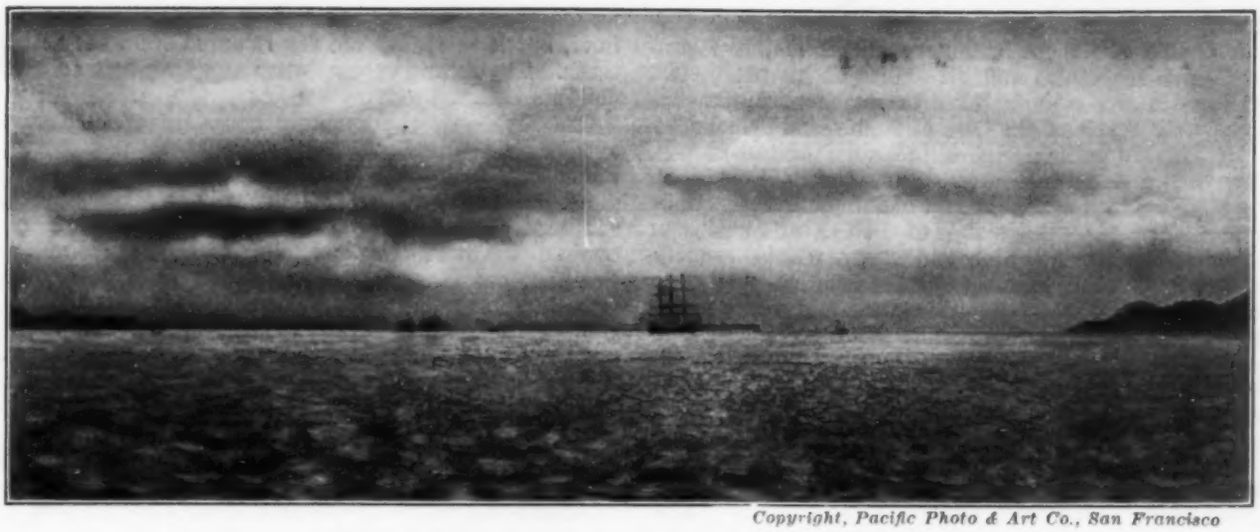
Power is obtained from the lines of the Utah Power & Light Co. at 12,000 volts, and is transformed to 440 volts at the mill. The larger motor driving the crusher system is a Westinghouse, the others being General Electric. The list of motors follows:

No.	H.P.	Duty
1	75	Driving one 10 x 20 Blake crusher, one 48-in. Symons crusher, one trommel and 24-in. conveyor, 12 ft. long.
1	15	Driving 24-in. conveyor belt 210 ft. long, and one trommel
1	35	Driving one Akins classifier, two Franz jigs, and a tailing excavator.
1	100	Driving one set 14x36 rolls, Franz tailing trommel two centrifugal pumps, 15 Wilfley tables, Richards-Janney classifier, and four elevators.
1	40	Driving two Harz jigs, six impact screens, and one elevator.
1	50	Driving 16 propellors of the flotation machine, and 14 concentrate skimmers.
1	15	Driving one Harz tailing jig, and one centrifugal pump.
1	3	Driving 18-in. belt conveyor, 270 feet long, with drop of 12 ft.

The total horsepower installed is 333.

For the opportunity of visiting the plant I am indebted to H. G. MacMillan, general manager of the Daly West Mining Company; for courtesies extended at the mine, to E. L. Talbot, mine and mill superintendent, and for data used in this article and generous aid in preparing the flowsheet, to J. C. Thompson, mill foreman.

Salt Lake City, Utah.



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San Francisco Meeting of the American Institute of Chemical Engineers

TO try and write the story of the seventh semi-annual meeting of the American Institute of Chemical Engineers would be trying to do something impossible. The best we can do is to give an account of the official proceedings of the San Francisco meeting, held from Aug. 25 to 28.

Of course, in such a dry record the real charm of the meeting is lost. Such charm is individual. Everyone who was happy enough to go West this summer has his own story—a story of meeting at the most unexpected places Eastern friends and sharing their pleasure and enthusiasm inspired by the West. On a fine Sunday morning the writer found himself sitting next to Dr. S. P. Sadtler of Philadelphia in a Santa Fé dining car in New Mexico; on the next morning, on the rim of the Grand Canyon in Arizona, he was stopped by the smiling face and outstretched hand of Prof. James R. Withrow of Ohio State University, and on the same afternoon, at Grand View Point, he met Mr. Ernst Boley of the American Steel & Wire Company, and so it went on until, in San Diego, he made connection with Dr. J. C. Olsen's official party of the American Institute of Chemical Engineers, including Professor and Mrs. Edward Bartow of the University of Illinois, Miss Bartow and Miss Abbott, Mrs. and Miss Darrah, Dr. E. E. Reid of Johns Hopkins University, Professor and Mrs. H. C. Enders of Cooper Union, New York; Dr. W. L. Klotz of the Barrett Manufacturing Company, New York; Mr. W. H. Ulrich of Cooper Union, New York, and Mr. H. E. Zitkowski of the American Beet Sugar Company of Rocky Ford, Col.

Of the San Diego days and the meeting of the Institute at Los Angeles we have given an account in our issue of Sept. 1. At San Francisco the headquarters were at the new and very comfortable Hotel Plaza, on Union Square. The three technical sessions on Wednesday, Thursday, Friday, Aug. 25, 26, 27, were held in the Civic Center Auditorium in San Francisco, in the chemical laboratory of the University of California in Berkeley, and in the chemical laboratory of Leland Stanford University in Palo Alto respectively.

On Wednesday afternoon an excursion was made to Protrero, where the oil gas works were inspected and the interesting new process of manufacturing oil gas was explained by Mr. Edward C. Jones.

On Thursday evening a subscription dinner at Tait's was immensely enjoyed, while Saturday was given over to an excursion to Winehaven, with inspection of vineyards and wineries.

It goes without saying that San Francisco outdid itself again in hospitality. While it is impossible to give credit to all to whom credit is due, Prof. J. M. Stillman of Leland Stanford and Prof. Edmund O'Neill of the University of California must be especially mentioned as untiring in extending courtesies to their visiting friends.

WEDNESDAY MEETING

The meeting at the Civic Center Auditorium was called to order by Prof. J. M. STILLMAN, who presided during that session. After a very cordial speech of welcome by the representative of the Mayor of San Francisco, there was a brief business session, in which it was decided that the winter meeting will be held in Baltimore and the meeting in summer, 1916, in Cleveland.

The first paper was then presented by Mr. A. M. MCAFEE on "The Improvement of High-Boiling Petroleum Oils and the Manufacture of Gasoline as a By-product Therefrom By the Action of Aluminium Chloride." This paper is printed in full on page 592 of this issue.

Dr. ARTHUR L. LACHMAN, the distinguished author of that charming little book on "The Spirit of Organic Chemistry," followed with a very interesting paper on "The Engineering Features of Wine Making." Limitations of space force us to withhold the abstract of this paper for our next issue.

THURSDAY MEETING

Prof. EDMUND O'NEILL presided at the meeting on Thursday in the chemical laboratory of the University of California in Berkeley.

The first paper presented related to "Costs as Applied to Professional Businesses," the author being Dr. RALPH A. GOULD of San Francisco. "The professional man sells service directed by systematic training in contrast to the unskilled workman who sells simply service, and in further contrast to the manufacturer or merchant who sells material. All are entitled to remuneration as a result of their labor. The first and the last are, furthermore, entitled to profit because of their in-

vested capital, in one case training, in the other capital. The profits of the professional man are mainly dependent upon his ethics and his ability at his profession, while with the manufacturer or merchant profits are largely the result of the laws of supply and demand."

Dr. Gould's paper describes in a very interesting way how with a partner in a consulting chemical engineering business they figure the cost of doing business. Their figures show the exact status of each client's business; how much they made or lost and exactly when they made or lost it; whether members of the firm are putting in too much time on unprofitable work and whether the connection with an unprofitable client should be continued on the same basis. They show the average profit derived from profitable clients and give valuable figures upon which to base estimates relative to new contracts and "overhead" clients.

Dr. Gould's paper is of considerable originality and deserves the attention of all consulting engineers and chemists.

Mr. EDGAR BARUCH of Los Angeles then presented a paper on "Resources and Possibilities of Chemical Industry in the Southwest." This interesting paper, which is published in full at the end of this report, elicited quite an extended discussion, in which Dr. Olsen, Mr. Beckman and Dr. O'Neill participated.

The last paper of this session was presented by Dr. OTTO BEST of San Francisco on "Manufacture of Cream of Tartar." This authoritative paper is published in full on page 613 of this issue.

FRIDAY MEETING

Dr. S. P. SADTLER of Philadelphia presided at the meeting on Friday in the chemical laboratory of Leland Stanford University in Palo Alto.

The following four papers were presented at this meeting:

"The Present State of the Thiogen Industry," by Prof. S. W. YOUNG.

"The Smelter-Fume Problem and Agriculture," by Prof. J. P. MITCHELL.

"The Purification of Sewage By Aeration in the Presence of Activated Sludge," by Prof. EDWARD BARTOW.

"Cottrell Processes of Electrical Precipitation," by WALTER A. SMITH.

Limitations of space force us to reserve abstracts of these papers for our next issue.

* * *

Resources and Possibilities of Chemical Industry in the Southwest*

BY EDGAR BARUCH

Generally the "Southwest" is designated as that portion of the United States lying west of the crest of the Rocky Mountains and south of the northern line of California, Nevada and Utah, a territory which includes all of these states as well as all of Arizona and portions of Colorado and New Mexico. The facts of this paper have been purposely limited to the confines of California and Nevada, though enthusiastic Californians might have suggested that the single name California be substituted for the "Southwest." Some "Native Sons of the Golden West" often state that were California to be severed from this continent or even the rest of the world by some cataclysm of nature, the State would in no way lack any of the natural resources which are the basis of the comforts and luxuries of modern civilized communities. This statement like many others emanating from California is difficult for strangers to believe, but is in reality not far removed from the actual truth. The following considerations may help to bear out this fact.

Geographically the northern boundary of California and Nevada extends 525 miles on lat. 42 deg. north; the eastern side of Nevada is on the 114th West Meridian; the southern line of California is about 32 deg. south lat.; and the western boundary of California extends along more than 800 miles of the shores of the Pacific Ocean in a general northwesterly by southeasterly direction. California alone curiously covers the extreme distances both north and south and east and west, and these are so great that they have an important bearing not only on great variations in climate, but also in transportation problems and the development of resources.

California has an area of 158,000 square miles and a population, according to the 1910 census, of 2,377,000—(not counting the rich tourists). Nevada has an area of nearly 111,000 square miles and only 81,875 population. Just for comparison note that the combined area, 269,000 square miles, are greater by more than 25 per cent than the total area of France with its 40,000,000 population, or Germany with its slightly greater area and 65,000,000 people, while California and Nevada have a combined population of only approximately 2,500,000, of which about half are rather closely congregated in comparatively small areas in the vicinities of San Francisco and Los Angeles.

Of course, the surface areas of California and Nevada are not comparable with those of France and Germany in the ability of those countries to support a large population per square mile, for not much more than one-third of the area of California is arable, about one-third is mountainous (though largely covered with timber) and the rest is desert, while almost the entire State of Nevada is barren waste of desolate desert and parched mountain ranges on which even jack rabbits and coyotes cull but the leanest pickings of a meagre existence.

The rainfall varies from almost nothing in the desert regions to 50 and 60 inches per annum in the northwestern counties of California. With but few local exceptions the climate is divided into a short wet period and a relatively long dry spell, but the large streams of central and northern California flow the entire year, fed by the everlasting snows of the high Sierras.

In California there are two great mountain ranges, the Coast Range Mountains paralleling the entire coast and the Sierra Nevada Range which runs from Shasta in the north to Tehachapi in the south. These mountains well above 10,000 ft. in altitude run at a greater continuous unbroken height than the Rocky Mountains. They culminate in Mount Whitney at 14,502 ft., the highest point in the United States outside of Alaska, and from this point, but for low intervening ranges 8500 ft. in height it would be possible to look down into the lowest region of this continent, the floor of Death Valley several hundred feet below sea level.

In the upbuilding and subsequent faulting of the continent the mountains, particularly the Sierras, were left with very abrupt eastern fasures and relatively gentle western slopes. This accounts for the general direction of nearly all California mountain streams being westerly; there are practically no large streams running toward the east. Between the great mountain ranges in California there is an immense valley, which converges toward its center to empty its drainage into the ocean through the "Golden Gate," the only low break in the Coast Range. The two branches of this valley, the Sacramento and the San Joaquin, are traversed

*A paper read before the seventh semi-annual meeting of the American Institute of Chemical Engineers, San Francisco Meeting, at Berkeley on Aug. 26, 1914. Very slightly abstracted.

by rivers of the same names which flow together in the delta region east of San Francisco Bay. The great valleys have been built up of thousands of feet of mountain erosion and owing to the variation in climate, ample water on the eastern sides, and rich soils, are highly fertile and adaptable to almost every conceivable crop. The costal valleys are relatively small, but numerous and conform in various positions between the spurs and ridges of the more or less irregular minor ranges. Those most important are Eureka, Santa Rosa, Santa Clara, Pajaro, Santa Maria, Santa Barbara, Ventura, the Los Angeles and San Diego and their tributary valleys and Imperial Valley. Owens Valley running north and south takes the small eastern run off of the Sierras which for ages collected in the basin of Owens Lake. This water is now being partially tapped from the Owens River as a source of water supply for Los Angeles City, by the great project of which you have all undoubtedly heard.

From a glance at the map you will note that the great desert of the State of Nevada is literally interlaced with one continual succession of short mountain ranges, nearly all of which run north and south. In between these ranges, owing to the lack of water, the floors of the valleys are rather steeply sloping with the detrius of boulders, rocks and sand of the slowly decomposing surrounding hills. In the entire State there is not one stream worthy of mention whose run-off ever reaches the ocean. In consequence such torrential storms as at times visit local districts, drain rapidly into pocketed basins or valleys, of which there are hundreds, where they ultimately evaporate in the form of dry lakes of concentrated alkali salts. These same conditions occur in like manner in the southern desert region of California where the saline deposits have been of more interest for no other reason than their more favorable geographic location.

Having thus shown you in a most cursory manner a few of the facial features of the country let us attempt to trace therefrom a few of the facts which have made these characteristics of such great value as natural resources of inestimable wealth.

TRANSPORTATION FACILITIES

There are harbors all the way down the coast from Eureka to San Diego. San Francisco possesses probably the most wonderful harbor in the world, large enough to shelter every vessel of the globe (even before the Germans and the English started their efforts to put ships at the bottom of the sea). There are splendid open roadsteads at Ft. Bragg, Monterey, San Luis Obispo, Santa Barbara, Santa Monica and Redondo and well-protected harbors at San Pedro and San Diego.

The San Joaquin and Sacramento Rivers are both open to transportation for several hundred miles.

Streams like the Trinity and Eel Rivers and the perpetually snow-fed streams of the Sierras, the Feather, Butte, American, Merced, Kings and Kern Rivers as well as a dozen others are some of them already furnishing hundreds of thousands of electrical horsepower and are capable of supplying millions more.

MINERAL SUPPLY

The ribbed and scarred mountains besides being the source of water-power and timber offer an infinite array of minerals.

The "49ers" in their mad scramble for gold overlooked most other metals, minerals and resources. It was not until the discovery of the Comstock Lode that attention was even devoted to the silver lead ores and nearly fifty years elapsed before any copper was produced from the Shasta district and later in Nevada at Ely, Ludwig and other places. There are numerous reasons for the slow progress in the development of the mineral resources; transportation facilities were lacking; the technique of handling and milling ores was crude; cyaniding was unknown, which made only placer and free milling gold ores of high value available; water-power could only be utilized from wooden wheels at dam sites, and steam power by the expensive use of wood as fuel in timbered districts. Because coal oil and gas were unknown smelters did not exist and processes for handling complex ores have only been developed during comparatively recent years, by the concerted efforts of the chemists with the mining engineers—efforts which are still proceeding with unflagging energy and are daily budding into new and successful processes and methods. Think, for example, of the development of the Pelton and turbine wheels for power, the marvelous evolution of the dredges, the economies of the cyanide processes, the Cottrell improvements for obviating smelter fumes and the new processes for leaching copper ores.

The California gold production since 1850 has amounted to $1,600,000,000 and is still nearly $20,000,000 per annum. Nevada has produced $400,000,000 and now furnishes $12,000,000 gold annually. The low prices of lead and silver put such a quietus on the production of these metals that their important deposits have been all but forgotten.

California and Nevada still produce more than 85 per cent of the quicksilver from the United States, about 15,000 to 18,000 75-lb. flasks per year.

Platinum has long been found in the sluicing and dredging operations on the Trinity River and northern streams of the Sierras, but no consistent efforts were ever made to trace the occurrences to their sources. Quite recently some enormously rich deposits have been found in conjunction with zinc, in the Good Springs country in southern Nevada. Pockets of ores have been found running as high as $11,000 platinum, palladium and gold to the ton. The fact that the ore looks like a rusty clay probably accounts for ignorant prospectors having tramped over the ground for many years without cognizance of the wealth beneath their feet.

The zinc regions thus far known seem to be fairly well concentrated from Ivanpah to Good Springs. The occurrences are in the form of both calamine and sphalerite.

Tin was developed from cassiterite ores at Temescal in Riverside County some years ago, but the deposits are now lying idle.

Antimony has been long known, but shipments have only recently been started and a smelter is now in operation at San Pedro.

Bismuth has been found in veins south of Banning, and arsenic occurs frequently with gold ores on the Mother Lode. Chrome is found in large quantities on the western slopes of the southern Sierras.

Manganese is almost of common occurrence. The largest deposits are in the Coast Range mountains of Tehema and Mendocino Counties, at Tesla in Alameda County and in the Chocolate Mountains of Riverside County.

A Los Angeles engineer recently published a most illuminating article on the iron deposits of southern California in which he shows that by the most conservative estimates there are over 200,000,000 tons of iron ores available in the Providence, Eagle and Kingston mountains, all adjacent to railroads. The deposits average 64 per cent iron content against 55 per cent ores from the Mesaba Range, and there are fewer impurities, such as phosphorus, sulphur and silica. Is it not remarkable that with a yearly consumption of 900,000 tons of steel, and with limestone, fuel and nearby coke available, that these deposits remain untouched?

Not far distant from the iron are manganese and the only working deposits in the United States of tungsten. The electric smelting of iron at Heroult proved too expensive to be practical and the plants have been given over to the production of ferro-manganese. We have thus far badly neglected our opportunities of furnishing this country with high-grade steels.

The extent of the limestone formations, even in the southern sections, alone, almost beggar description. At Sloan, Nevada, range after range of mountains stand hundreds of feet above the floor of the desert solid unbroken masses of high-grade limestone. At many other points westward all the way to the coast there are hundreds of millions of tons of exposed lime rock. Big cement plants are to be found at Oro Grande, Colton and Riverside, also in the north at Santa Cruz, Napa Junction and Cement, while the lime deposits occur in the mountains all the way to the northern boundaries of the State.

Relatively, magnesite is of but small occurrence, though Califronia is the only State in the Union producing it. There is a small deposit at Winchester, a larger occurrence near Mojave and mines are now being worked near Fresno, at Red Mountain and in Sonoma and Napa Counties.

Kaolin, china porcelain and pottery clays are found at Ione in Amador County and Placer County with feldspar and silica not far distant, yet California imports yearly $300,000 worth of china and porcelain from the East. Brick and tile clays occur in river bottom lands in sections too numerous to mention. From the dark heavy clay soils of the ground on which they squatted the early Spanish and Mexican settlers made sun-dried bricks, from which they built their adobe huts.

Silica in the form of quartz can be obtained almost everywhere and there are fine deposits of white silica for paints and glass-sands in Nevada.

Sulphur was mined for many years in Humboldt County, Nevada, and fairly large occurrences are just south of Goldfield, while a very large new discovery has just been reported from Kern County.

Most of the world's supply of borax comes from California, from the great Borax Smith mines in Death Valley and more recently from the Ventura County deposits of colemanite.

The deserts furnish gypsum, talc, celestite, baryte and salt in profuse abundance and the dry lakes contain untold millions of tons of soda in the form of both carbonates and sulphates. At Searles Lake, of unfortunate exploitation, the American Trona Corporation spent more than $500,000 for a railroad before they had so much as evolved a process for working their raw materials. They planned to recover from the lake brines primarily potash, also sodium carbonate, sodium bicarbonate, sodium sulphate and borax. Many of the sinks of Nevada contain a considerable amount of potash; and much harmful exploitation and ill-directed effort has been expended trying to obtain potash from the sea weeds and kelps of the coast, from which the companies have hoped to recover iodine as well as many organic materials.

Throughout the two States there are small or sporadic deposits of flourite, bauxite, molybdenite, nitre, graphite, mica, asbestos, jasper, ochre, pyrites and alum, not to mention a hundred other less important minerals.

Mineral water and springs of all descriptions, hot and cold, mud, sulphur, soda, salt and lithia are to be found.

San Diego County furnishes us with the lithium salts of lepidolite from Pala, and from the same region are derived the semi-precious gems of tourmaline, aquamarine and kunzite. Elsewhere we obtain moonstones, garnets, tourquoise, onyx, opal, sardonyx, crysoprase, cat's eyes, variscite, rhodenite, californite, beryls, topazes, jades, abalone and pearls, even sapphires and not to be behind Arkansas occasional diamonds are noted.

Fuller's earth, little of which has been utilized occurs in Nevada and in the San Joaquin Basin.

There are numerous deposits of infusorial or diatomaceous earth in both California and Nevada. Probably the finest and largest deposit in the world is at Lompoc in Santa Barbara County. Through the efforts of the owners and their research chemists the value of their product has been demonstrated in many different industries. According to the specific gravity and purity of the material it is used in such diverse fields as the manufacture of sugar, edible fats, light brick, as an insulating medium, etc., some forty patents having been applied for or issued within the last few years covering the applications of their products to new uses. This is only one indication of the possibilities of well-directed chemical industry in the use of heretofore disregarded material.

We have an abundance of building materials such as slates, rhyolites, trachytes, volcanic tuffas, obsidianites and basalts. Marbles are plentiful, but quarries near existing railroads generally appear to be badly faulted and shattered, though the main difficulties in obtaining good slabs can usually be attributed to the ignorance with which our western deposits have been worked. Excellent varieties of colored, veined marbles are found at Carrara, Nevada, and green malapi conglomerates are obtained from near Barstow. All forms and colors of granites and sandstones are available of which you have seen many beautiful examples in the buildings of Los Angeles and San Francisco. Our cities need not go as far as Rome went, for their paving blocks, macadams, rubbles, gravels, sands and building materials.

OIL

In some of the valley regions there are large deposits of peats. Lignites and coals occur in the Coast Range Mountains. But of far more vast importance to chemical industry have been the discoveries and development of petroleum oils and natural gas during the last twenty years. With a production of 7,000,000 to 8,000,000 bbls. of crude oil per month no one need longer worry about any possible lack of fuel supply for our industries. California has at this writing approximately 55,000,000 bbls. of oil in storage above ground. Since the inception of the industry in 1890 approximately 750,000,000 bbls. have been produced and nearly 90 per cent of this amount within the last ten years.

We are refining as much of our oil as the markets will take and make casing head gas, gasoline, kerosene, distillates, lubricants and asphalts, but in view of the enormous sources of hydroelectric energy available for power it would appear that in burning our surplus oil we are practicing a criminal wastage of our resources for which we can hardly expect our descendants to forgive us. We have indeed been unwise as well as profligate with our heritage of natural wealth, to an extent from which we of the younger generation and our immediate children will suffer the effects. This condition applies particularly to our careless even wilful wastage of natural gas encountered in drilling for oil and which we in our haste for the nearest dollar have allowed to escape us to the cost and comfort of future generations. To be sure we are now beginning to pipe some of the excess gas from the wells to the cities, but distances in this country are great, investments large and subsequent prices for the gas are high.

Water gas from crude oil is the basis of most of our artificial supply. The only efforts made to utilize the

by products of this industry are in the making of carbon briquets; the napthalines, pitches and tars are all wasted.

The increased use of direct combustion oil engines of the Diesel or semi Diesel type should do much to effect economies in the consumption of oil fuels.

The shortness of my time limits more than the mere mention of such well established industries allied to the mineral resources as acid and powder manufacture, the production of fertilizers, glass and heavy chemicals.

With this hop, skip and a jump I fear that you have gained only a very faint conception of the extent and variety of our mineral products, but suffice it to say that of these materials California alone produced $103,000,000 worth in the year 1914.

AGRICULTURE

Agriculturally the resources of Nevada are too small to warrant attention at this time, but California more than makes amends for the deficiency.

The great valleys which twenty years ago supplied little more than grain and cattle are to-day undergoing constant transition toward more intensive farming and diversified crops. Wheat, barley, oats and corn are still grown in enormous quantities and now-a-days large crops of rice, on what were formerly called goose or bad lands. Hops for the brewing industries occupy much of the bottom areas of the Sacramento basin. One will find vineyards all the way from Red Bluff in the north to Bakersfield in the south, with the attendant industries of raisin growing, wine making and sometimes the production of argols. Interspersed with the vineyards you will see orchards of cherries, almonds, peaches, pears, apricots and prunes. Asparagus, potatoes and vegetables of all descriptions are grown on the river islands and deltas. The valley foothills grow olives, lemons, oranges and grape fruit, and in the higher altitudes the best of apples.

South of San Francisco, along the coastal valleys as far down as San Juan Capistrano, approximately 125,000 acres of sugar beets are planted annually, which yield about 500,000,000 lbs. of sugar, an amount two and one-half times in excess of the needs of our own population, not counting the equally large output of Hawaiian sugars from the two refineries on San Francisco Bay. Chemically and technically the best sugar industry has reached a high state of perfection though there are still many opportunities for improvements, particularly along the line of investigative agricultural chemistry and in the utilization of the waste products. The plants which have only molasses as an end product sell their material to either alfalfa-meal mills or to the distilleries for the production of alcohol. Those plants which have installations of the Steffens recovery process, in general, still send their waste waters, which contain distinctly valuable amounts of potash and nitrogen, to the sewers. In one or two instances these waters are pumped on to the fields as fertilizer, other plants are making efforts to concentrate their waste waters in conjunction with their lime cakes for the production of marketable fertilizers. About 3.5 tons of potash have heretofore gone to waste with every 1000 tons of beets worked.

The southern valleys, generally subject to fogs during the summer months, are well adapted and produce, in addition to sugar beets, large crops of beans, walnuts and olives. A recent improvement in the olive industry is a process for extracting tannic acid by drying bruised fruit—or mincing the meat, boiling it in its own oil and canning the product. In addition to the production of olive oil we grow peanuts and make the oil and butter therefrom. A fact not generally known is that California is producing annually about 600,000 lb. of Turkish cigarette tobacco.

The citrus products for which southern California is so well known are grown in the foothills and the semi-high regions where the orchards are least affected by the frosts. It is only of recent years that much attention has been paid to the possibilities of utilizing the fruits to the fullest advantage, particularly the so-called culled fruits. The associations of growers are maintaining separate laboratories, besides the special government stations, attempting to work out processes for the production of citric acid, oils of orange and lemon, citron, candied peel, marmalade, orange butter, orange wine and orange syrups.

The new farming districts of Imperial Valley produce alfalfa, cattle and cantaloupes. The finest grades of long-staple cotton are grown in this district and the cottonseed oil and cake industry is naturally following in the wake.

The fishing and canning industries along the coast are worthy of special mention. Sardines from San Pedro have for many years been boiled in California oil and put on the market in French-looking cans. But an industry, all our own, established at the same point is the production of canned tuna. Salmon have been caught in the Sacramento and the northern coast streams since the beginning of our history. Oysters, the small varieties, quite different from the large eastern type, are found in the bay regions.

The gradual encroachment of orchards and intensive farming on the old princely estates of the land barons, who formerly owned 40,000 to 60,000-acre tracts, has also demoralized the old-time cattle ranches of the low lands. The grazing grounds have been gradually driven further back into the hills and mountains, and only when the grass becomes short or the cattle are to be fattened for the markets are they herded into the valleys for alfalfa, grass or grain feeding. Dried beet pulp is also attracting considerable attention and the entire output of three of the southern beet sugar factories is either steam or kiln dried and sacked for dairy fodder; other mills pump the extracted beet slices to silos where the water drains off in part and the remainder after souring is highly valued for cattle fattening.

Our packing house industries are, of course, diminutive compared to those of the Middle West, none the less we have our tanneries, soap works and other allied branches of this work. It is, however, worthy of note that our hides all go East to be made into shoes which have to make another trip across the continent for our use. The majority of our wool and cotton follow the same course. The only textile mills we have weave cotton bags and canvas. . . .

You have probably already been wondering why this brief catalog of our resources and industries is so lengthy. I have been trying to convince you with a short survey that Californians can make good their boast that they lack no resources to make and supply them with all necessary physical comforts. Nature was probably never more bountiful to any country than this Golden West. We possess the resources for great industries based on electrochemical, metallurgical, mineralogical, agricultural, horicultural, husbandry and forestry pursuits.

PRESENT INDUSTRIAL LIMITATIONS

Why have these not been more firmly established and grown to greater extents? Why do we ship our crude products to the east and foreign countries for fabrication without even taking through the gates of our cities, to have them shipped back to us in only slightly altered form for our consumption? Why are our harbors only

transient points for all the riches of the tropics and the orient? Why have we been so slow to realize and to utilize to the fullest extent the resources, and to materialize into tangible assets the long dormant possibilities of our western kingdom?

The reasons are numerous. View our "splendid isolation" with the vast Pacific on one side of us, high mountains and broad deserts on the other, an almost barren uninhabited peninsula on the south and long reaches to civilization on the north. There are only four mountain outlets from California, ranging from nearly 4000 to 7000 feet in altitude. Bear in mind that we are more than 3000 miles from the eastern seaboard, 2000 miles from the center of population in this country; that it takes 6 days to reach Hawaii, the nearest islands of the Pacific, and three weeks to Japan, China or the Philippines, by fast mail boats.

Our Empire is traversed by only three trunk line railways with but few branch and spur line ramifications into the surrounding territories, and these lines largely parallel each other. In consequence, ore and timber deposits, with the possible exception of precious metals, are almost valueless unless by chance they lie practically adjacent to existing transportation. It is impossible to haul salt, gypsum, talc, magnesite, soda, potash, chrome or manganese from 10 to 50 miles over desert or mountain roads with any hope of putting such products on even the local markets at a profit. The first question asked of the prospector is "how far are you from the railroad?" Though we still have amongst our population many hopeful prospectors, sturdy mountaineers and tanned desert rats, they have mostly learned that excepting for gold they cannot wander far from the iron rails. In consequence there are still great undiscovered almost virgin regions in both California and Nevada.

Irrespective of long hauls to the railroads we have had much to contend with from the railroads themselves. No better picture of this phase of our development, has ever been penned than by Frank Norris in the "Octopus" in which he vividly describes the bitter hatred of the California pioneers for the Southern Pacific Railroad of the days of Collis P. Huntington. Though the old railroad tyrant has been long dead they failed to bury all railroad abuses with him. However, since the Harriman régime the Southern Pacific Railroad has improved wonderfully and the competition of the Santa Fe and the Western Pacific and the State and Interstate Railroad Commissions have done much to better conditions.

I am informed that in the east it is possible to generally figure 3½ mills per ton mile on railroad haul for ores. The lowest rates of which I am aware in this country are 5 mills per ton mile on certain sections of the Santa Fe. The beet sugar people pay 7 mills per ton mile for 70,000 tons of rock per annum over 197 miles of track. Recently I had some cheap ores (silica) to be moved 200 miles in Nevada. The first quotations were $15.90 per ton, and it took much coercion and many weeks of voluminous correspondence to ultimately obtain a rate of $3.90. If you desired to ship desert sand or ordinary rock from Nevada 400 miles to Los Angeles you would have to pay $4.00 per ton freight (10 mills per ton mile); to San Francisco, 500 miles, you would have to pay $6.00 or 12 mills per ton mile. The glass factories in the bay region claim that they pay only $5 per ton for Belgian sands after they have been transported 20,000 miles.

The lowest ore rates to the East via the Panama Canal are $7 per ton. Via Galveston on the Southern Pacific there is a $10 rate, but all material must be sacked. The lowest all-rail rates are $12 per ton. This is sort of a blanket rate to the majority of the railroad centers throughout the country. It costs $12 a ton to ship low-value ores to New York, Boston, Chicago, St. Louis, Denver or Salt Lake City and as anomalous as it may sound you might have to pay anywhere from $15 to $18 per ton if you wanted to stop your shipment at any point before it reached even Salt Lake City, the nearest terminus.

Our labor problems present many difficulties. With the total exclusion of the Chinese and the restrictions on Japanese, Hindoo and Mexican laborers we have discouraged and retarded many big enterprises. We are in need of foreign labor, a moderate number of thrifty Chinese or busy Japs would be of decided advantage to this country. We do not need Greek and Neapolitan fruit venders or organ grinders to crowd our cities, but we do need fruit pickers and mill workers.

Life in the rural and mountain regions is generally most attractive. Hunting and fishing still abound and there are good roads thereto in almost every section.

The city conditions are not much different from other parts of the United States. San Francisco as a world harbor is very cosmopolitan, a small New York. For many years it has been burdened like the old man of the sea with Unionism and labor troubles, yet see with what majesty she recovered from her devastating ruins. Los Angeles, a very moral town, is the next to the last abiding place of most of the successful farmers of the Middle West and many other people who can raise the cash to pay the railroad fare to what they think is a land of ease and indolence. The chief industries of this branch of the population are real estate and insurance.

I trust that I may have conveyed to you that we produce a far greater quantity of raw products, fruits, sugars, cereals, textiles, timbers, fuels and minerals than the people within our own borders can consume. The difficulties which lie in the way of hindering more rapid development are the lack of sufficient and reasonably priced transportation facilities for getting our products to markets. The sparsely settled country and the lack of population particularly of working classes, is the cause not only of restricted *local* markets but also of high labor costs for all products. The newness of the country has called for immense outlays of capital for development purposes, but investments in our big industries seem to be attractive to even foreign money as is witnessed by the interests of the Dutch Shell Oil Company and the General Petroleum Company in our oil resources and there is also much foreign capital invested in our copper and gold mines. We still need vast sums to help sane, rational development, but we trust that we shall no longer be oppressed with the scandalous exploitation schemes of scoundrelly promoters.

There are at present more pregnant opportunities for the development of resources than in the days of the pioneers of '49. We are only in need of much strong, honest effort and staunch capital to back it to make this one of the richest countries of the world.

It is frequently said that when one once visits California the longing to return never ceases until one comes back to live. We hope *you* have caught the lure of the "Golden West" and that we will some day see all of you chemists and engineers, you men who accomplish things, back amongst us in the near future, helping us with your hands and brains to change our possibilities into realities, and helping us to put to the best uses of mankind our great resources.

The activity of Japan in mining is represented by the fact that there are more than 1500 mines in operation, 52 gold, 112 gold and silver, 53 silver, 175 copper, 536 coal, 161 oil. Others are antimony, iron, manganese, graphite, peat, sulphur, etc. Many employ the most modern machinery.

The Fleming Dust Collecting System*

BY W. C. HANNA

As visitors pass out of the large acreage of orange and lemon groves owned by the California Portland Cement Company, and come within closer view of the splendidly equipped mill at the foot of Slover Mountain, those familiar with the general appearance of cement manufactories notice a decided difference in this one. There is something lacking which is common to the industry—or has been in years gone by. There are no kiln and dryer stacks with their objectionable trail of dust and fumes.

How it is possible to have such a condition in a factory of this size is explained by the buildings at one side of the plant, from the end of which large volumes of water vapor are pouring. These buildings and the machinery connected with them constitute the Fleming patent dust collecting system, which is receiving much attention from cement manufacturers throughout the United States, and back of which lies a history of interest to all connected with the cement industry.

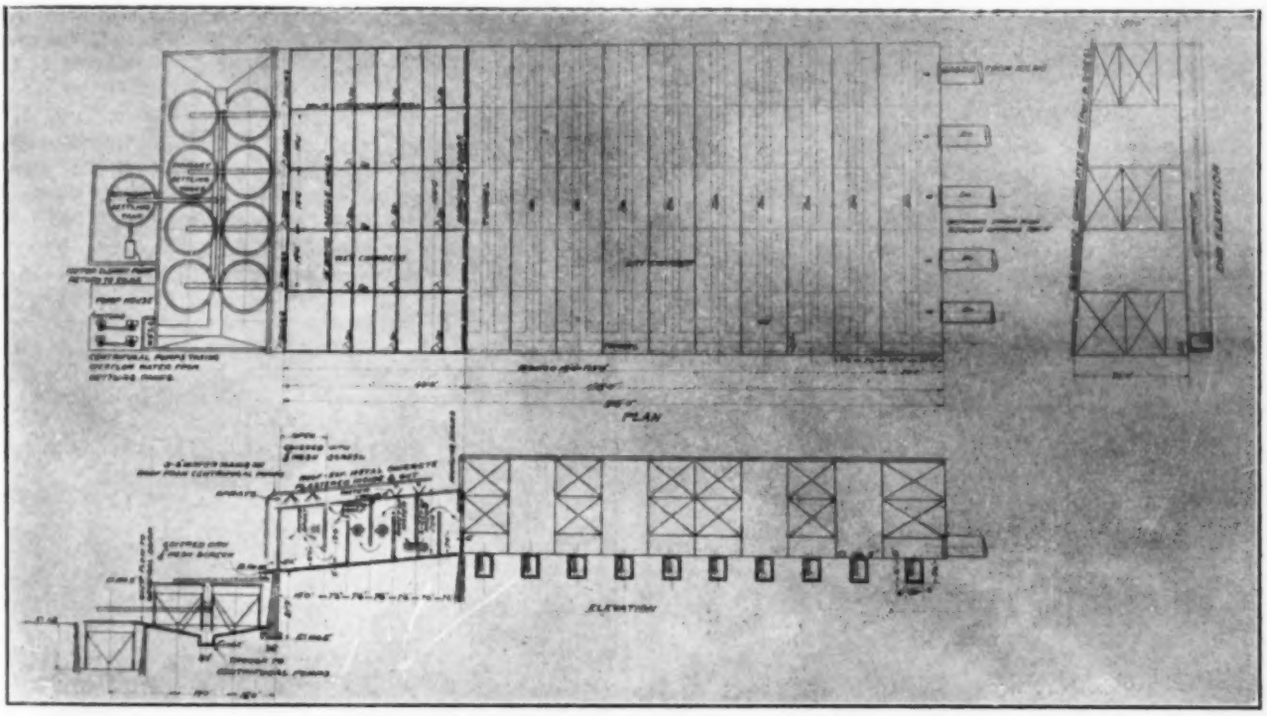

FIG. 1—THE FLEMING PATENT DUST COLLECTING SYSTEM

Orange growers in the vicinity of Slover Mountain began to complain in 1909 about dust emanations from the kilns and dryers of the cement plants operated at Colton. At that time the new or largest plant was one of the most modern in the United States and was considered by cement manufacturers a clean plant, and as there had never been any recorded injury to people or vegetation in the neighborhood of cement mills, the orange growers' complaints and threats were believed to be without grounds, but serious enough, however, to warrant an extensive line of investigations and experiments with all known methods for capturing the dust.

These investigations were continued with zeal, but nothing of sufficient effectiveness was found. In the meantime the orange growers, not being satisfied with the efforts of the cement company, brought suit against it and, in the trial during July and August of 1910, expert testimony from many parts of the world covered much of the field of cement manufacture, dust collecting devices, and agriculture as practised in the vicinity of Colton.

The Superior Court granted the orange growers an injunction in April, 1911, which became effective in June of that year, but, by that time, experiments at the old cement plant had proved so satisfactory that Mr. T. J. Fleming, secretary and general manager of the company, had most of the material on the ground for constructing his dust collecting system on a practical scale for five rotary kilns 7½ ft. in diameter and 120 ft. long. By September, 1911, the first kiln was operating to the dust house and, shortly afterwards, all of the kilns were operating at full capacity with the Fleming System. Meanwhile, throughout the mill, a campaign against dust was made, resulting in all grinding machines, elevators, and conveyors being made practically dustless.

The orange growers were not yet satisfied with the efforts of the Cement Company and brought suit for contempt of court. The evidence was such that the court was not satisfied, so he appointed Dr. R. E. Swain of Leland Stanford University, as an impartial expert to make an examination of the system and report to him.

Dr. Swain's very complete investigations were made in February, 1912, and the report, which he made shortly afterwards, was so favorable that the court dismissed the case stating that the plant as operated was not a nuisance and was not being operated in contempt of court.

This same system of dust collecting has been in continuous use since that time and has proved to be, not only an efficient means of capturing the dust, but also to be more than self-supporting, there being a saving to the company in the dust captured, better output per barrel of fuel oil, and less shut downs than before the Fleming System was in operation.

*A paper read at the seventh semi-annual meeting of the American Institute of Chemical Engineers, at Los Angeles, California, on Aug. 18, 1915, in joint session with the Southern California Section of the American Chemical Society. An account of this meeting was given in our issue of Sept. 1, page 530.

PRINCIPLE OF SYSTEM

Very briefly, the installation consists of normal rotary kilns using dry process and oil for fuel. The draft for the kilns and dryers is produced by fans sucking at the end of separate flues. Instead of discharging the gases into the atmosphere, the same exhauster fan blows the dust and fume into a large chamber known as the dry dust settling chamber where the velocity of the gases is reduced about 90 to 95 per cent, resulting in a large amount of dust being deposited. The extremely fine dust which does not settle and the gases then go to the wet washing chambers where the gases are forced up and down several times while following a serpentine course through a system of seven baffle chambers, and the last of the original so-called cement dust is captured by sprays of water which are in each chamber. These sprays of water also bring into solution much of the gases, lime and alkalies. In connection with both the dry and the wet chambers there are means provided for removing the captured dust to the cement kilns.

DESCRIPTION OF PLANT

This paper will describe a unit in connection with three kilns 8½ ft. in diameter and 150 ft. in length with a capacity of 31 barrels of clinker per kiln hour, or about 2200 barrels per day, also one clay dryer which handles all of the clay used at the plant. This is the third large unit installed at Colton, each new unit, as

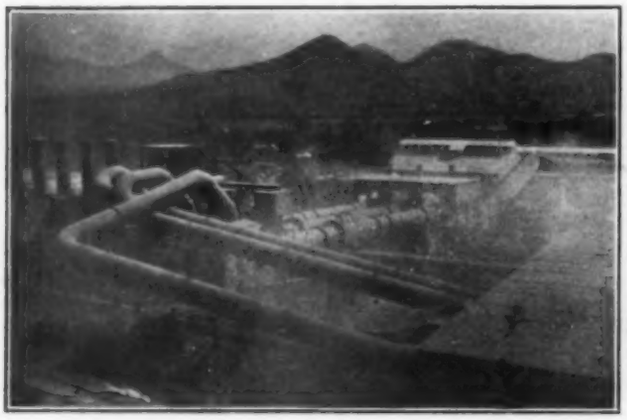

FIG. 2—THREE KILNS AND FLUES LEADING TO FANS

The clay dryer flue is seen below the three large flues. Part of dry dust chamber shown in lower right hand part of picture. Sawed off stacks, with seal on top for five kilns 7½ ft. by 120 ft. seen in the extreme left.

installed, having a few improvements over the preceding one. The house has capacity for two more kilns of this same size.

The fans which produce the draft in the kilns are located at the end of what would normally be the stacks to the kilns, but which in this case are about 180 ft. long and which, instead of being perpendicular, first rise from the stack base at the feed end of kiln then curve over and slope downward toward the fans. Each kiln is provided with a separate flue, fan and motor, so that the operation of any one kiln is independent. The flues are 6½ ft. in diameter, lined with fire brick for the first 20 feet, and they are provided with the necessary expansion joints.

The fans are of special exhauster type made by the B. F. Sturtevant Company. They are 5 ft. wide and 10 ft. in diameter, equipped with water cooled bearings and operate at a speed of about 145 r.p.m., each fan being driven by a 40 hp. motor, although only 11.7 hp. is required except when fan is first started. During the past year of continuous service there has not been a single hour lost due to fan trouble.

The results obtained by the kilns determine the speed at which fans are to be operated. Sometimes it is found to be desirable to give the kiln more draft, and the fan is operated at a faster speed, while at other times the reverse is true. The ease with which the draft in the kiln can be regulated is of great assistance in the economical operation of the rotary kilns.

A Thwing pyrometer is used in connection with the installation, the thermocouples being located in the flues near the fans, and the recorder in the kiln room where the cement burners can regulate the fires keeping the temperature at the fans not higher than 900 deg. Fahr. This together with the perfect control over the draft and of the speed of the kilns, makes the condition ideal for the manufacture of Portland cement clinker. The draft, induced as above, has proved to be far easier to control than a stack draft, the life of the kiln lining is almost permanent, provided kiln is not allowed to get cold, the ring formation reduced, and the clinker produced more uniform in quality.

DRY DUST SETTLING CHAMBER

The discharge from the fans is just about the same as from an ordinary kiln stack, only the blast is horizontal instead of perpendicular and at an elevation that is convenient for treating the gases laden with dust in the dry dust settling chamber.

This chamber into which the fans discharge the gases

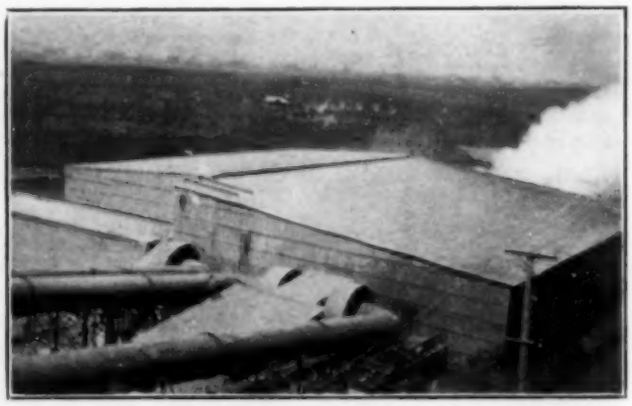

FIG. 3—THE FAN WITH PART OF FLUES

Also dry dust chamber, and water vapor pouring from the wet baffle chambers.

is 150 ft. long, 100 ft. wide and 31 ft. high. It is a steel frame structure, with sides and roof covered with corrugated galvanized iron in order to promote radiation of heat.

There are no barriers to a free passage of the flue gases within this chamber, except a set of baffle plates about ten feet wide extending across the chamber in a line about thirty feet in front of the inlet flue openings.

The temperature of the gases as they go to this chamber is 700 deg. to 900 deg. Fahr. and on emerging from the same the temperature is 300 deg. to 400 deg. Fahr. Due to this reduction of temperature, and to the large area of the house there is a 90 to 95 per cent reduction in the velocity of the flue gases, resulting in about two-thirds of the suspended dust particles or about thirty to forty tons of dust per day being deposited in this dry chamber.

There are ten cross tunnels beneath the floor of this department, and in each tunnel there is a screw conveyor with steel troughs and ten spouts, with gates, leading from the floor above into the conveyor for drawing off the dust.

Each of these cross tunnel conveyors discharge into

the conveyor running in the main tunnel and it, in turn, connects with a conveying system which carries the dust to a bin in the raw mill building. The dust is drawn from this bin and properly mixed with the material being fed to the kilns.

WET WASHING CHAMBER

The gases, with the remaining dust, go to the wet baffle chamber which is the same width as dry chamber and 60 ft. long. The frame work is of steel, the sloping floors are of concrete, the walls of brick and concrete, and roof of expanded metal encased by concrete.

It is divided into five separate compartments, each 60 ft. long and 20 ft. wide.

Each compartment receives the gases from the dry chamber through two openings, 6½ ft. by 9 ft., which may be closed by means of hanging concrete doors operated vertically from the roof.

Only three of these compartments are required and the two not in use can be kept in reserve in case any of the others should require new sprays or other work done on them.

Each of these compartments has six transverse baffle partitions alternately rising from the floor and descending from the roof, leaving six foot transverse openings through which the gases are forced, over the first baffle and under the second, and so on until they pass under the sixth baffle, emerge into the exit chamber, and through the roof, which is made of one-half inch mesh wire screening. The actual area of exit openings for each compartment is about 135 sq. ft. and the velocity of the gases about 250 ft. per minute.

FIG. 4—DRY CHAMBER AT LEFT, THEN WET BAFFLE CHAMBERS, THEN SETTLING TANKS

Each baffle section in each of the five compartments is provided with a set of water sprays. The return water from the settling basins is used in all of the sections except the last one. Each spray with return water is adjusted to carry about twelve gallons of water and each fresh water spray delivers about six gallons per minute. In these wet baffle chambers the remaining one-third of the dust in suspension is removed and the temperature of the gases reduced to about 125 deg. Fahr. at the exit.

The water with its load of dust, falls to the sloping floor and runs to the end of house, where it falls into a screen covered trough extending the entire length of the end wall of the wet baffle chamber. Lateral troughs lead from this to the center of each of the eight primary conical, steel, settling tanks, 16 ft. in diameter.

The overflow from these, being almost free from suspended matter, falls through the open air, in order to cool it, to the reservoir below from which it is pumped as return water at about 100 deg. Fahr. by centrifugal pumps, back to the sprays.

The thin slurry from the bottom of the conical primary settling tanks is syphoned through gooseneck pipes to a common trough which leads to a secondary conical settling tank.

The clean overflow from this also goes to the common collecting reservoir, but its thick slurry, containing about twenty pounds of solids per cubic foot, is pumped to the slurry tank above the kiln stack bases from which it is continually fed to the rotary kilns.

The amount of water required to operate the Fleming system is much less than at first would be expected. The fresh water need not exceed 75 to 100 gal. per minute, and it has been found desirable to add this in the form of coarse sprays in the exit chamber, above the screen to the same, and in the baffle chamber just before exit chamber. The greatest part of the washing is done by the circulating water which amounts to at least 1000 to 1200 gal. per minute. The heaviest sprays of return water are located in the second baffle chamber after leaving the dry chamber.

The amount of dust captured each day in the dry dust chamber is about thirty to forty tons, while about fifteen tons is captured in the wet baffle chambers.

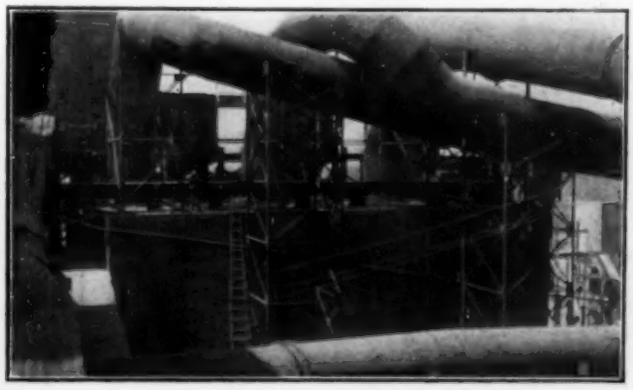

FIG. 5—THE KILN FLUES LEADING TO FANS

The flue at bottom of picture leads from the clay dryer to the dust house.

Where only rotary kilns are operated in connection with the dust collecting system, the proportions of calcium oxide, silica and alumina found in both the dry dust and slurry are found to be such that they can be returned to the kilns without special attention being given to them. Where dust from dryers, such as clay dryers, is also collected in the same system the dust will contain an excess of clay and it must be returned with proper care. At the Colton plant the dust is used so as to balance any irregularities in the composition of the raw mix as it goes to the kiln feed bins.

UTILIZATION OF THE COLLECTED DUST

The method of using the dust will probably be of interest so I will briefly tell you how it is blended.

The rotary kilns and the dust collecting system are in operation twenty-four hours each day, while the clay dryer operates at night long enough to fill the empty clay bins. The slurry from the wet baffle chambers, after being thickened in the tanks, is pumped about every hour over kiln stack bases to a tank holding almost one day's run, and the slurry kept in agitation by compressed air. The hundred spouts under the dry dust chamber are opened daily, only on the day shift,

and the dust conveyed to a bin of almost one days' capacity in the raw grinding department.

The amount of dust deposited in the collector from the kilns is very uniform and from the amount of clay used one day it can be closely estimated how much clay will be deposited in the chamber that night to be mixed with the kiln dust for use the next day and night.

The raw mix, as proportioned at the scales, is made of such composition that the dust must be added to it in order to give a suitable composition. The dry dust can be added to the ground raw mix at any desired speed, and from one to fifteen raw mills can operate without causing inconvenience. When everything is normal, the miller operates the dust feeder at a specified speed for each different number of mills that he may be operating, but in case the raw mix, as tested in the laboratory, is found to require a little more or less clay the laboratory orders the dust feeder to be speeded up or reduced sufficiently to give the desired mixture. As the dry raw mix runs into the kilns, a small stream of the well-mixed slurry from the slurry tank runs by gravity into the kilns.

The dust captured in the dry dust chamber is very fine, practically all passing a No. 200 sieve and about 97 per cent passing a No. 300 sieve. Both this dust and the extremely fine dust captured in the form of

FIG. 6—EXIT WATER

A—Water with load of dust falling from sloping floors into main trough. B—Lateral troughs over settling tanks. C—Surface of water in settling tanks.

slurry have much more sulphur, potasium and sodium than the raw mix, but after a few returns to the kilns they do not show any further increased percentages of these elements.

The water used in the wet baffle chambers very rapidly becomes heavily laden, chiefly with sulphur compounds of potasium, sodium and calcium, and when more than half a pound per cubic foot is found, some of the water is taken out and replaced by fresh water in order not to cause trouble with the sprays. Plans are being made to recover the potash.

The dust which is discharged into the air from the exit to house amounts to about one ton per day. This dust bears no resemblance to the original cement dust, it being for the most part sulphur compounds of potasium, sodium and calcium and about 88 per cent to 94 per cent soluble in water. This dust is produced by the draft drawing out the fine sprays of water from the wet washing system much the same as the wind carries inland the salt-water spray from ocean breakers.

LABOR AND POWER.

The Fleming system requires very little labor. The power consumption is reasonable, not exceeding 2000-kw. hours per day, of which 57 per cent is used on the return water pumps.

The cost of placing the Fleming system in an old plant would depend upon the general layout of the plant, the amount of room available and type of construction. In a new plant the apparatus can be placed with ease and at minimum cost.

In concluding my remarks with the customary contrast of results "before and after using," it is impossible to deal exclusively with the unit used thus far in this paper, as that unit has always operated with the dust collector in connection. Therefore, it will be necessary to take results obtained with one clay dryer and

FIG. 7—KILN FLUES

Which first rise from stack base, then come over and slope downward toward the fans.

five kilns, 7½ ft. in diameter and 120 ft. long, which were operated for about 2½ years with normal practice, and then for the same length of time with the Fleming system.

With this dust collecting system in use there was obtained:—(1) About 24 per cent more clinker per barrel of fuel oil consumed; (2) about 5 per cent more clinker produced per hour of kiln operation; (3) about 2 per cent more actual operating time of kilns; (4) over 7 per cent less raw materials required for manufacturing a barrel of cement; (5) the quality of the output was improved; (6) dust from dryers and kilns collected and the nuisance abated.

California Portland Cement Company,
Colton, Cal.

Manufacture of Cream Tartar*

BY OTTO BEST

The history and development of the manufacture of cream tartar and its allied product, tartaric acid (Rochelle salt), in this country is a phenomenal one. Its rise began with the use of cream tartar as a constituent for baking powder, for which, by far, most of the cream tartar is being used.

From a small industry thirty to thirty-five years ago, it has developed in this country to a production of about 1,500,000 to 2,000,000 lb. per month.

It is a general belief that a goodly portion of this product derives its raw material from California, the more so as California produces on an average 35,000,000 to 50,000,000 gal. of wine annually.

However, as a matter of fact, California furnishes only a very small portion of the total used, about 400,000 to 500,000 lb. purity on raw material per year, which is not even one-half the monthly consumption of this country. The rest of the raw materials come mainly from France and Italy, very little from other countries.

RECOVERY OF RAW MATERIAL IN CALIFORNIA

A good many efforts have been made in California to recover more tartrate raw materials. The high-grade goods, argols, are saved completely. The lees, however, are not fully recovered. Most of the large wineries have recovery plants for this product, in which the main stress is laid on the recovery of the alcohol in the lees, the latter being distilled off as brandy.

The lee recovery in this case is, therefore, only incidental and not the main purpose. This is partially due to the low value of the product in comparison to the wine and brandy, and partially on account of the high labor and dirty work in connection with this work. At any rate, the recovery of lees in California is anything but complete.

EXTRACTION OF POMACE

A number of years ago there were several plants in California that aimed at recovery of tartrates from pomace, the residue left after the pressing of the grapes. These plants contributed for a number of years toward the production of tartrate raw material. They disappeared, however, entirely, mainly on account of changed conditions in the industry.

There is no doubt in my mind that with the application of modern means a good deal more tartrate could be recovered in California. The rapid strides of the temperance movement, and adverse legislation, no doubt has a depressing effect on the industry and has greatly stifled the enterprise in this direction.

RAW MATERIAL

The raw material is partly in the form of lees, a product averaging about 35 per cent cream tartar, with varying amounts of calcium tartrate, say 2 to 5 per cent, which is deposited by the first fermentation. It consists of about two-thirds dead yeast, with sulphur, wood chips, etc., and one-third tartrates. This product is, however, mainly used in Europe for the manufacture of tartaric acid.

ARGOLS AND LEES

The raw material in this country for cream tartar is mainly argols, the secondary deposit in the wine barrels after the fermented wine has been drawn off from the settled lees. This product averages about 70 per cent in cream tartar and 5 to 7 per cent in calcium tartrate.

Where gypsum is being used for the removal of some tartrates from wine, much more calcium tartrate is present. Such argols, very high in calcium tartrate, are used for the manufacture of tartaric acid.

The refineries of cream tartar are always connected with the manufacture of tartaric acid, as calcium tartrate and impure mother liquids of cream tartar have to be converted into tartaric acid. At least there is no technical method worked out on an economic basis which would permit reconversion of those impure products into cream tartar.

As the demand for tartaric acid is comparatively small, its manufacture is more or less considered a necessary evil, and its production reduced to a minimum.

There have been a number of processes employed in refining cream tartar.

Neutral Process

One of the earliest in the United States, at least, which appeared, but as early disappeared, was the so-called neutral process. It aimed at neutralization of cream tartar by alkali, and then precipitating again by acid according to the following equations:

$$2KHT + Na_2CO_3 = 2KNaT + CO_2 + H_2O$$

The KNaT was separated from the pulp by filtration, and the solution precipitated as follows:

$$2KNaT + H_2SO_4 = 2KHT + Na_2SO_4$$

About the practical details I know little. No doubt the process failed on account of the costly chemicals used, and technical difficulties.

Settling Process

The so-called *settling* process was successfully used for a number of years and, though rather crude, has decided advantage over the "neutral" process on account of its simplicity and cheapness of operation.

It was used in two modifications, which modifications refer to the working up of the residue into tartaric acid after extraction of most cream tartar.

The crude material was first ground and charged into a large wooden cooking tank, with a perforated copper basket, about 30 in. in diameter, reaching down to the bottom. The heating of the mother liquor to boil was carried out through long copper coils, while the basket was charged with live steam to keep the crude material in suspension.

It was the opinion of the cream tartar manufacturer that this stirring had to be very violent to get all cream tartar in solution. The basket had to "dance," as the official expression was. The wood chips and undissolved cream tartar passed through the holes of the basket and settled outside the basket.

After full charge was made with a solution of from 3 to 3½ per cent, china clay was added in order to make the suspended matter settle faster and more completely. The more china clay, the better, was another axiom of the refiner of the old day.

After settling, the fairly clean solution was drawn off into wooden or, later on, copper crystallizers.

The aim was to get large crystals, in order to be able to remove the mechanical impurities by a washing process, and these large crystals were only obtainable by a low saturation. While full saturation of cream tartar in pure solution is 6.9 g. in 100 c.c. at 100 deg. C., the real strength was rarely over 3.5 g. per 100 c.c.

After cooling, the cold mother liquid was pumped back again to be re-charged, and this process carried on so often until the mother liquor was too impure, and was then sent to the tartaric acid department to be worked into tartaric acid.

*A paper read at the seventh semi-annual meeting of the American Institute of Chemical Engineers, at Berkeley, Cal., Aug. 26, 1915.

WASHING OF FIRST (BROWN) CRYSTALS

The large, brown, cream tartar crystals, with much mechanical impurities, were crushed; that is, the aggregates broken up into large individual crystals, and these stirred up by mechanical devices.

One of these devices was a revolving drum, the so-called *rumbler*. The heavy crystals stayed on the bottom, while the lighter impurities would stay in suspension and could be drawn off from the crystals. The muddy mother liquor was used for tartaric acid manufacture. The crystals, if needed, were washed a second and a third time with mother liquor, until pure.

ACID TREATMENT OF FIRST CRYSTALS

The crystals, thus obtained, contained on an average 90 to 92 per cent cream tartar. The rest was mostly calcium tartrate, a little coloring matter, traces of iron, gypsum at times, etc.

The calcium tartrate cannot be removed by recrystallization, as it is freely soluble in a hot solution of cream tartar, from which it crystallizes or deposits, as cream tartar crystallizes on cooling. It is, therefore, removed by acid. To this interesting reaction I shall come back later on.

This washing with acid was usually combined with the removal of the mechanical impurities, as described before.

After the removal of excess acid by water, the crystals tested 98 to 99 per cent in cream tartar, though the earlier *finished* products averaged only 95 per cent in cream tartar.

REMOVAL OF CALCIUM TARTRATE BY COOKING UNDER PRESSURE

I wish to mention here a process which, for some time, was considered the only commercial process of removing calcium tartrate, and thus getting high-grade cream tartar.

It consisted in dissolving the crystals containing calcium tartrate under about 100 lb. pressure. Under this pressure calcium tartrate, with 4 molecules of crystallization water changes to the anhydrous compound, which is almost insoluble, more so in pure than in impure solutions. Through filtration and crystallization a high-grade cream tartar could be obtained. This process has been entirely abandoned.

RECRYSTALLIZATION

The 98 to 99 per cent product obtained was dissolved again, decolorized with lime-free bone black (bone black treated with hydrochloric acid), china clay added to settle bone black, and the settled solution crystallized in copper crystallizers of considerable size.

The crystals obtained from this solution were washed, dried, and ready for shipment.

The heavier mud from first (brown) cooking tank was charged and leached a second time, while the lighter mud was used as raw material for the manufacture of tartaric acid.

ACID TREATMENT OF MUD

In some factories this mud was treated with sufficient sulphuric acid to decompose all tartrates, bring them in solution, and filter and wash the mud in filter presses.

The clear solution was then neutralized with lime, or carbonate of lime, to precipitate the tartrates as calcium tartrate, an insoluble compound, and remove the potash and other impurities by washing.

DIRECT NEUTRALIZATION OF MUD

In other factories the neutralization was carried out without removing the mud. In this case the reaction takes place in two phases:

$$2KHT + Ca(OH)_2 = CaT + K_2T + H_2O$$
$$K_2T + CaSO_4 = CaT + K_2SO_4$$

If the precipitation is carried out right, the calcium tartrate is granular and heavy, which settles quickly, while the suspended matter settles very slowly. If wash water is drawn off before mud has a chance to settle, soluble and insoluble impurities are removed at the same time.

The process is very simple and avoids the cost of acid and the costly filtration. Yield is also satisfactory, so that the crude settling process has the preference over the acid filtration process.

However the calcium tartrate is obtained, after complete removal of all impurities, it is decomposed by sulphuric acid into gypsum and tartaric acid, the latter worked up as further on explained.

I wish, still, to state that this settling process was, for a number of years, practically the only process carried out successfully on a large scale.

High-Pressure Process of Cream Tartar Extraction

This process was the first attempt of getting the raw material in a filterable state, in order to remove the impurities right from the start, instead of carrying the mechanical impurities all through the process.

There is no doubt that the removal of the impurities from the start is sound in *principle*, though not always possible in practice, without too much sacrifice. Let us see how this process attempted the solution of the problem:

Argols or lees were ground and cooked under about 100 lb. pressure for about two hours. Through this cooking, all albumin and other constituents detrimental to filtration, were destroyed. At any rate, the solution, after this treatment, was filterable.

The clear solution, after filtration, was run into crystallizers and crystallized and otherwise treated as described, with this difference that mechanical impurities were removed by filtration and need not be removed by a "rumbler."

This process was mainly used for low-grade goods, lees. From a technical and mechanical standpoint it works well. However, the loss on raw material is very large, particularly in presence of calcium tartrate.

Systematic investigations have shown that the loss on cream tartar was in direct proportion to the amount of calcium tartrate present. The latter seems to decompose more readily than cream tartar. The lime forms fresh calcium tartrate, which again is decomposed, etc.

A further drawback of this process is that the mother liquors become very soon discolored and syrupy and have to be discarded.

Last, but not least, a pressure process, especially with an acid product, is never a desirable process technically. For these and other reasons it is to-day practically abandoned. It is interesting from a historical standpoint, mainly because it introduced filtration, and with it modern methods in the manufacture of cream tartar.

Roasting Process of Extracting Cream Tartar

We now come to the latest process, the so-called "roasting process."

Argols or lees are roasted at a temperature above the decomposition point of albumin, organic coloring matter, etc., but below the decomposition point of cream tartar and calcium tartrate. This temperature is around 150 deg. C.

The effect of this roasting is marvelous. While argols and lees, when extracted without roasting, are practically unfilterable, just a few dark-colored drops passing through the filter, after roasting the solution passes the filter almost like water, the filtered solution is absolutely clear, and of light straw yellow color.

The roasting is, therefore, not only for the purpose of an increased filtration, but is a great purifying process as well. The mother liquors from the roasted goods can be used over again much longer than from unroasted goods.

DIFFERENCE OF ROASTING AND HIGH-PRESSURE PROCESS

You will note the big difference between the two processes which aimed at filtering: The first process, cooking under pressure, increases the coloring and extract matter going into the mother liquors, and causes big losses on tartrates, besides larger technical difficulties.

The second process, dry roasting, improves the mother liquors by decreasing extract and coloring matter, is carried out *without any loss* on tartrates (I refer here to losses due to this roasting), as experiments on a small and large scale and operations on a technical scale for years have conclusively proven. It is, furthermore, simple and efficient.

After roasting, the raw material is ground coarsely and extracted in wooden vessels with agitators. Boiling is avoided. The charge is now filtered through bronze filter presses into copper crystallizers, and allowed to crystallize for four to five days. The filtration is very rapid.

With a pressure not to exceed 50 to 60 lb., 24,000 gal. could easily be filtered within about three hours without cleaning filter press. Whoever has tried to filter cream tartar will appreciate the technical success of this process.

The amount of filter cloth used was very low. With a monthly production of about 150,000 lb. cream tartar, the bill for filter cloth for this department was below $100.

As the labor and other items in connection with the roasting process and filtration are also low, and the yield on cream tartar much higher, than with the other processes, the roasting process must be considered the only rational and modern process.

COMPLETE EXTRACTION OF MUD WITHOUT ACID

The leached out mud is extracted a second and a third time with cream tartar mother liquor in a systematic way, and is then practically free from tartrates. It is not necessary to give this residual mud an acid treatment, or send it to the acid department. It is sufficiently low in tartrates to be discharged. It still contains some phosphates, nitrogen, potash, and can, therefore, be dried and used as a filler for fertilizer.

Another great advantage of this process is that the saturation of the solution can be much higher than with the settling process. The saturation can be brought up to 6 per cent (with the settling process about 3½ per cent), as we need not to settle nor depend on large crystals, as the cream tartar crystals are free from mechanical impurities. This, naturally, cheapens installation and manufacture.

FIRST (OR BROWN) CRYSTALS FROM ROASTING PROCESS

The brown crystals test about 90 to 92 per cent in cream tartar. The rest is calcium tartrate, as mentioned in the description of the previous process. The calcium tartrate crystals are usually yellow, and adhere to the edges and corners of the cream tartar crystals, as they crystallize out *after* the cream tartar is practically crystallized out.

They can clearly be distinguished from one another, as the cream tartar crystals have sharp edges and corners and are transparent, while the calcium tartrate crystals look amorphous, are not transparent, and are usually uniformly colored through a trace of iron. If free of iron they are white, but not transparent.

REMOVAL OF CALCIUM TARTRATE FROM RED CRYSTALS

On account of this property, that the calcium tartrate crystals stick to the surface of the cream tartar crystals (do not permeate the cream tartar crystals throughout), they can be dissolved in acid without fine grinding of cream tartar. The cream tartar crystals are merely crushed into individual crystals, and then treated with acid. These reactions in this connection are very interesting, as one (the first one) is reversible. Here are the reactions:

$$KHT + HCl \leftrightharpoons KCl + H_2T$$
$$CaT + 2HCl = CaCl_2 + H_2T$$

The first reaction is reversible, for the reason that cream tartar is almost insoluble in KCl solution. The solubility of pure cream tartar in a 10 per cent KCl solution is 0.04 g. cream tartar in 100 c.c. The stronger the KCl, the greater the tendency of forming cream tartar back again. In reacting back, free hydrochloric acid is formed, which is capable of dissolving calcium tartrate. Thus the free hydrochloric acid is neutralized and more KCl can act on H_2T and form cream tartar and HCl. The hydrochloric acid again acts on the calcium tartrate, etc., etc.

PURITY OF ACID-TREATED CREAM TARTAR CRYSTALS AND LOSS ON CREAM TARTAR TO TARTARIC ACID

As stated, the reverse action takes place the more, the stronger the solution. For this reason I add strong hydrochloric acid, 20 to 22 deg. Bé to the fairly dry cream tartar, just enough to cover it. This is about equal in weight with the calcium tartrate.

Investigations showed that in the first twenty-four hours the purity was raised usually to about 95 per cent, while the mother liquor contained about 2 parts of cream tartar to 1 part of calcium tartrate (figured as calcium tartrate).

After forty-eight hours the purity would rise to 97.5 to 98 per cent purity, while the mother liquor contained about 1 part of cream tartar to 1 part of calcium tartrate in solution.

After seventy-two hours the purity of the cream tartar was usually 99 per cent, or above, and the mother liquor contained now about 1 part cream tartar and 2 parts calcium tartrate.

These are average figures from practice, and change according to concentration of hydrochloric acid and temperature; but mainly with the size of calcium tartrate, which varies considerably.

As will be seen, time is the essential factor of this reaction.

These figures were obtained when no agitation or stirring was applied.

Comparative figures, under vigorous stirring for a comparatively short time, say one-half to one hour, demonstrated that the amount of cream tartar in solution and the amount of hydrochloric acid were both much larger in the latter than in the former case.

In a previous chapter I mentioned that the manufacture of tartaric acid in this country was, more or less, considered a necessary evil. Since the hydrochloric acid solution of tartrates can only be worked into tartaric acid, it is important that as little as possible of the cream tartar is dissolved by the hydrochloric acid. Long standing with hydrochloric acid dissolves comparatively little cream tartar.

More cream tartar can be precipitated from this hydrochloric acid solution by partial neutralization of the excess hydrochloric acid.

The brown cream tartar crystals thus treated with hydrochloric acid are washed with water, and test now over 99 per cent in cream tartar.

RECRYSTALLIZATION AND DECOLORIZATION

They are redissolved, decolorized with boneblack, filtered and crystallized a second time, washed, dried, and are now colorless crystals of over 99.5 per cent in cream tartar.

When the white mother liquor does not furnish pure crystals any longer, it is discharged into the red batches. A corresponding amount of red cream tartar liquor is discharged into the tartaric acid department.

LOSS IN MANUFACTURE

The loss in manufacture of cream tartar is comparatively small, as all the impure products which cause the loss are discharged into the tartaric acid department.

This transfers the difficulties and losses merely from one department to the other.

The loss in the cream tartar manufacture are partially due to fermentation, which loss is very low, practically nil, with the roasting process; larger with the other processes.

FERMENTATION OF CRUDE MATERIAL

The fermentation may start with the raw material, stored away, when the same had not been completely dried. In order to establish this loss, a cream tartar test (Klein test) is made from the raw material and a potash determination, and the latter figured into cream tartar. If this figure is higher than the direct determination, loss through fermentation of raw material has occurred.

LOSS THROUGH COOKING

Some loss is due to cooking, possibly a little through roasting, though a direct determination never disclosed a loss in either direction.

There is no further source of loss, outside of some mechanical loss.

Manufacture of Tartaric Acid

We now come to the manufacture of tartaric acid. As indicated above, all products of cream tartar manufacture too impure for cream tartar are transferred to the tartaric department.

The various sources are: impure cream tartar, mother liquor, and the tartrates from the hydrochloric acid treatment. No mud need be treated in the roasting process, as the extraction in the cream tartar department is complete.

MANUFACTURE OF CALCIUM TARTRATE

These products are transformed into calcium tartrate, an insoluble compound, which can be washed for the removal of the impurities.

If we manufacture calcium tartrate from cream tartar crude material, two steps are needed, as explained before. These products, with excess hydrochloric acid, form enough $CaCl_2$ to precipitate the neutral tartrates as calcium tartrate without further addition of gypsum.

SOLUBILITY OF CALCIUM TARTRATE

The solubility of pure calcium tartrate is about 1 part in 6000 parts of cold water. This solubility is raised to 1 in 500 parts in *hot* water. It is well, therefore, to neutralize cold, if large losses are to be avoided.

Impurities in solution affect the solubility of calcium tartrate. $CaCl_2$ and KCl *decrease* the solubility of calcium tartrate. All other impurities seem to *increase* the solubility of calcium tartrate. Organic substances in solution, for instance, considerably increase its solubility; so do iron and aluminum salts, phosphates, sulphates, etc. This is the main reason why the loss in manufacture is transferred from cream tartar to tartaric acid.

PROPORTION OF CREAM TARTAR TO TARTARIC ACID

Usually only about 10 per cent of the production of cream tartar is obtained for tartaric acid manufacture, and by skillful manipulation it can be kept much lower. Correspondingly, the impurities in the tartaric acid department are increased. It needs very careful operation and full control of all operations to keep the loss down.

LOSS THROUGH PRECIPITATION AS CALCIUM TARTRATE

This precipitation entails the biggest loss of any individual step. It needs, therefore, the most attention and study. It also needs full attention, as in this step the impurities are removed, and if fully removed will make subsequent steps easier and losses smaller.

The neutralization was carried out by some manufacturers with lime, but most manufacturers use now carbonate of lime. After neutralization, the calcium tartrate is washed by decantation until all impurities are removed. This has to be done swiftly, as otherwise calcium tartrate will ferment and cause loss.

EVAPORATION OF TARTARIC ACID

The pure calcium tartrate is decomposed with a very small excess of H_2SO_4 evaporated at low temperature, say not to exceed 170 deg. Fahr., usually at first in open evaporators, then in vacuo, until saturated hot, and then run into crystallizers. The cooled-off mother liquor is evaporated a second, third, etc., time, as long as it still forms good crystals. Last impure liquor is reprecipitated.

All crystals are washed, dissolved, decolorized, filtered, evaporated and again crystallized to form commercial tartaric acid.

If evaporation is carried out in open vessels, the temperature has to be controlled carefully, otherwise large losses on tartaric acid will be incurred.

META-TARTARIC ACID

Another source of loss is due to the formation of meta-tartaric acid. This acid is formed through evaporation in open vessels, especially in presence of impurities. It is supposed to be a semi-anhydride of tartaric acid, non-crystallizable, with calcium and acid potassium salts much more soluble than the ordinary tartrates.

If present in larger quantities, tartaric acid will not crystallize, though evaporated much above the saturation point of tartaric acid.

Reprecipitating cold with lime or calcium carbonate will entail a large loss on account of the higher solubility of the calcium meta-tartrate over the ordinary tartrate of lime. When this calcium meta-tartrate is heated to boil, it is changed back to the ordinary calcium tartrate, and after decomposition with sulphuric acid will give crystallized tartaric acid again.

In a well regulated factory with vacuum evaporators, meta-tartaric acid will not be found.

A number of years ago I worked out an approximate determination of meta-tartaric acid. I did not follow it up for the reason that I prevented its formation.

The brown tartaric acid, as it comes from the crystallizers, is washed, dissolved in water, decolorized, evaporated in vacuo to saturation hot, crystals taken out after five or six days' standing, washed, dried, screened, and are now ready for shipment.

The mother liquor is evaporated a second and third time, as long as good crystals are obtained, and the last white mother liquor returned to the first brown.

REPRECIPITATION OF TARTARIC ACID AS CREAM TARTAR

There used to be a process of working up the last brown tartaric acid in order to recover cream tartar and to remove the impurities at the same time. This mother liquor, which contains many impurities and free sul-

phuric acid, was diluted, and the free sulphuric acid neutralized by lime. The gypsum formed was filtered off, and the remaining clear solution treated with excess KCl.

The reactions taking place were as follows:

$$H_2T + KCl = KHT + HCl$$

Considerable hydrochloric acid is being formed, when about 5 per cent KCl is in excess.

But there are impurities present, such as Fe, Al, K, etc., which will combine with the free acid and make precipitation more complete, while the metals stay in solution as chlorides, and are removed as such.

I give the following reaction as an illustration:

$$Al_2T_3 + 3KCl + 3HCl = 3KHT + 2AlCl_3$$

The two reactions are, of course, simultaneous.

This process, I believe, is abandoned, as it was too expensive on account of the costly potash salts used, and the large loss on tartrates. However, it was one practical attempt to revert tartaric acid into cream tartar, at the same time removing the impurities.

OTHER PROCESSES OF TARTARIC ACID MANUFACTURE

I wish to state that where tartaric acid is manufactured, not as a by-product of cream tartar manufacture but as the main or only product, as in many European countries, a number of processes are known for the manufacture of tartaric acid. These processes, however, are outside the scope of this paper, as we are in the first case interested in the industries as they were called into existence in this country through economic conditions.

REFINING IN ONE OPERATION, OR CRYSTALLIZATION

In general, I want to stay that some attempt has been made, both in cream tartar and tartaric acid manufacture, to refine these products in *one* crystallization, and I myself have carried out many experiments, without, however, having gone beyond the laboratory scale. Short cuts of this kind are very tempting, because of the shortening of the process and consequent smaller investment and cheaper productions. Such attempts have been successful in other branches of manufacture, like boracic acid, borax, etc. But to the best of my knowledge no such process has successfully been carried out in the manufacture of cream tartar and tartaric acid in this country.

In France, I was informed, a process was introduced on the line of the *neutral* process, which claims pure cream tartar in one operation. How successful it is technically, I cannot tell.

To reiterate: Of all processes advocated and carried out in America, the only survivor seems to be the "roasting process," which, in some form or other, is practically carried out in every large cream tartar refinery in this country. It is rational, because it removes the impurities, and with it the trouble *from the start;* it permits the introduction of modern filtering apparatus and appliances, without being too costly, to offset these advantages. It is a clean process from beginning to end, easily and fully controllable.

It gives high yield and rather *avoids,* than cures, trouble and disease.

These, in my mind, are the chief characteristics of a modern process, of which the "roasting process," in connection with cream tartar manufacture, is an example.

San Francisco, Cal.

The California Slime Extraction Company, of Setter Creek, California, is installing a 5 by 10 ft. adjustable quick-discharge tube mill of Chalmers & Williams, of Chicago Heights.

Gold Milling in California—A Comparison

BY LEROY A. PALMER

Practice at the various mills in the Gold Belt of California presents a striking uniformity. The first mills used only amalgamating plates. Then the vanner came into use to treat the tailings which frequently carry a large portion of the values in connection with iron sulphides or "sulphurets," which name still clings in this country. Usually the vanners treated the pulp without any previous classification. Chlorination and, later, cyanide plants have been installed for the manufacture of bullion from the concentrates. During the past three years there has been a departure from standard practice on the part of two companies which have constructed and are operating all-sliming cyanide plants. These mills, the Globe Consolidated at Dedrick, Trinity County, and the Black Oak, at Soulsbyville, Tuolumne County, are the only ones treating gold ores in which amalgamation does not form the first step in the treatment.

This clinging to methods that have become obsolete in many other districts does not indicate lack of progress on the part of California millmen. Most of the ores, especially of the Mother Lode, are readily susceptible to this simple treatment and elaborate refinements would not yield such an increase in saving as would justify the additional expense. For this reason progress along the line of ore treatment in this district has been mechanical rather than metallurgical. The Mother Lode ores have the larger portion of their values in the free state, and every mill in this district depends on plates for the greater portion of its recovery. But as one leaves the Mother Lode proper and goes to one of the adjoining districts, such as the East Belt, he finds many mines at which the free values are in much smaller proportion and the treatment of the sulphides becomes more complex although the general similarity of the ores still obtains.

Two of the new mills in the Gold Belt are the Plymouth Consolidated, at Plymouth, Amador County, on the Mother Lode proper, and the Black Oak, at Soulsbyville, Tuolumne County, on the East Belt. They present an interesting comparison, as aside from the fact that each uses batteries for primary crushing, they have not a single point in common, although they are treating ores not greatly dissimilar. Yet each one is undoubtedly well chosen to meet the particular conditions under which it operates.

Plymouth Consolidated Mill

The Plymouth Consolidated mill, which commenced operation in August, 1914, represents the latest stage in the development of standard milling practice in the Mother Lode district. The Plymouth ore is typical of the "stringer leads" of this belt, consisting of alternating bands of quartz and slate, with considerable clay. The gold occurs free and in connection with "sulphurets," which are principally pyrite and arsenopyrite.

Crushing and Conveying

The ore is hoisted from a two-compartment and manway shaft in automatic dump skips and discharged to a small bin of 125 tons capacity. From this bin it is fed through a hand-operated sector gate to a 5K Gates crusher driven by a 35-hp. motor. It is of a friable nature, and consequently breaks in the stopes with a large proportion of fines, and the coarser chunks contain a considerable amount of clayey matter.

On this account it was found that the usual practice of separating the coarse and fine over a grizzly would result in an irregular feed to the conveyor. To obviate this the entire run of mine is sent through the

crusher, which is kept buried under ore and acts as a feeder to the conveyor to the mill bins. This method provides the conveyor with a regular feed without overloading, as would be the case if a grizzly were used, and when there would be times when practically all of the ore would pass through it to the belt and little or none would go to the crusher.

The Plymouth shaft is located in a flat so that it is impossible to deliver the ore to the top of the mill without a considerable elevation. The crusher is set below the level of the ground and discharges to an 18-in. "Lamina" rubber belt conveyor, the housing of which is shown at the left of the illustration (Fig. 1). This conveyor has a lift of 108 ft. and a horizontal length of 631 ft. It is driven in two sections, one 350 ft. and one 310 ft. long on the slope, with 10 and 15-hp. motors respectively. The inclination of the belt varies, but, as can be seen by referring to the illustration, the greater part of the lift comes on the second section, hence the necessity of a larger motor for the shorter belt. This portion of the conveyor attains a slope of 21° 30′, corresponding to that of the roof of the mill, and very nearly equal to the maximum on which these ores may be conveyed without rolling or sliding. The inclined belt discharges to a horizontal belt 85 ft. long driven by a 10-hp. motor and carrying a tripper by which the ore is distributed in the bin at any desired point. Link-belt equipment is used throughout the conveyor system. After handling approximately 110,000 tons of ore in eleven months, the rubber belts in this system show practically no wear, a strong argument in favor of the economy of the best class of equipment.

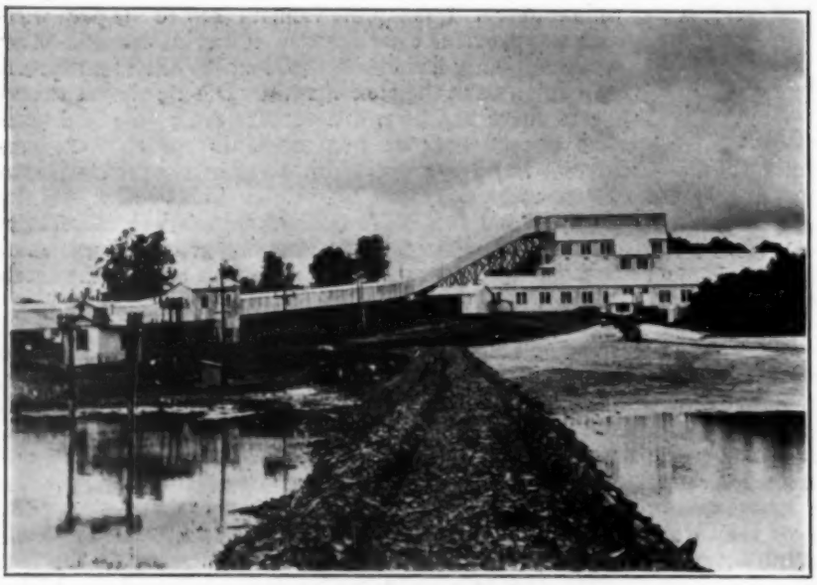

FIG. 1—PLYMOUTH CONSOLIDATED MILL

Fine Crushing and Grinding

The mill is of timber frame construction, with corrugated iron sides and roofing. As the illustration shows, it is well supplied with windows and skylights. It is well lighted at night by numerous large tungsten lamps. The floors are of concrete. The ore bins, which have a capacity of 1200 tons, are of heavy timber with flat bottoms. They are so proportioned that about 30 per cent of the ore, practically a day's run, will discharge from them by gravity, leaving a reserve supply of 840 tons which can be shoveled out in case of emergency. This is somewhat more than necessary to keep the mill running two days, 380 tons being the standard operating capacity.

The mill bins discharge by means of Challenge feeders driven from the stamp stems to thirty stamps arranged in six batteries of five each. Only five batteries are used at a time, except as noted later. The mortars are set on heavy concrete piers tied with crossed bolts. This gives a very satisfactory foundation and the batteries are practically free from vibration. The weight of the stamps used on Mother Lode ores has been gradually increased from time to time, and those at the Plymouth, weighing 1250 lb., are the heaviest yet installed, although they have a close second in the Black Oak to be mentioned later. The dies are set for a discharge from 5½ to 6½ in., the end dies being set ½ in. higher than the others. The tappets are set to give a drop of 7 in. and are allowed to wear to 7½ before taken up. The speed is 100 drops per minute, and the order 1-3-5-2-4. A 100-hp. motor drives the batteries.

The batteries crush through a six-mesh screen (No. 60 Rektang), which gives a free opening of 0.087 in. The pulp is collected in two launders, one to each fifteen stamps. These launders, unite, but after passing a sampler divide again and each goes to two classifiers in series. The first classifier is merely an inverted wooden pyramid measuring 20 in. on the upper edge, and the second is a 36 in. steel cone. These classifiers, so called, are in reality "sloughing off" devices, no counter current of water under pressure being employed and the separation being the result of the difference in the rate of settling of the various particles. The underflow of both classifiers of a series goes to the feed end of an 8-ft. by 22-in. Hardinge mill and the overflow is laundered to the discharge end of the mill. The

FIG. 2—HARDINGE AMALGAMATOR, PLYMOUTH MILL

slate in the ore is pretty well pulverized in the process of stamping, so that most of it overflows from the classifiers and the principal feed of the mills is pure quartz.

The mills have been watched closely and several tests made to determine the capacity and consistency of the pulp at which they would develop their highest efficiency. The dilutions of pulp tried were from 1 solid to from 0.666 to 0.950 water and various rates of feeding were tried out. As a result of these experiments it was found that the mill does its best work at a capacity of 140 tons per twenty-four hours with a pulp consisting of 1 part solid to from 0.70 to 0.75 water (Sp. Gr. 1.76-1.79).

An old hoist motor rated at 200 hp. is used to drive the tube mills, elevators and concentrating tables. This motor is very much larger than is actually required, as it is estimated that the power consumed by each tube mill is only 40 hp. Following is an average of the screen analyses of feed and discharge over a considerable period.

Size	Feed	Discharge
+ 20	30.0-40.0	0.5- 1.8
+ 30	20.0-25.0	5.5- 9.0
+ 40	11.0-13.0	10.0-13.0
+ 60	12.0-16.0	23.0-26.0
+ 80	4.5- 7.5	12.0-15.0
+100	2.5- 4.0	7.0-10.0
+200	3.0- 4.0	10.0-14.0
—200	3.0- 4.0	15.0-20.0

The minus 200 discharge of the mill was tested for sands and colloids by diluting with a large proportion of water, agitating and decanting all solids that would not settle within two minutes after agitation ceased. The process was repeated five or six times, and it was assumed that such solids as remained after the last decantation were in granular form and that all of the slime had been removed. According to these tests only 5 or 6 per cent of the discharge of the Hardinge mills is in the form of slime.

Danish pebbles are used in the mills with a consumption of 1½ lb. per ton of ore when the best grade of pebbles can be obtained. Local pebbles were tried and given a fair test, but it was found that their consumption was 6 to 7 lb. per ton of feed, and that the difference in cost was not sufficient to offset the difference in the amount used.

Amalgamation

Fifty-five to 70 per cent of the gold in the Plymouth ore is free. Forty per cent of the free gold is in flakes of appreciable size, greater than 1/64 in. in diameter. This makes it advisable to practise amalgamation in two stages, as any attempt to catch all of the gold, both coarse and fine, on one set of plates would result in an inordinate amount going into the plate tailings and thence into the concentrates. This is a result to be avoided if possible, as the smelter does not pay full value for the gold recovered from that source, and there is the further possibility of loss in the table tailings. Standard Mother Lode practice has been disregarded in that no attempt has been made to amalgamate in the batteries, although amalgamation in the Hardinge mills was tried when operations were first commenced. This was successful so far as the actual recovery of the gold was concerned, but was attended by a rather high loss of quicksilver and much inconvenience in cleaning up, and consequently was discontinued.

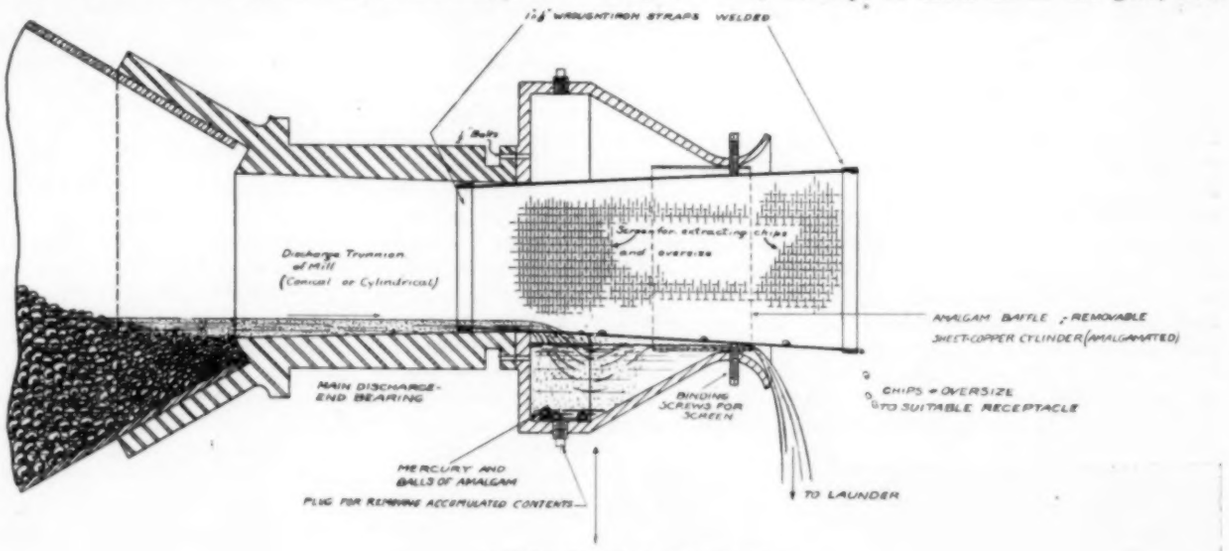
1¼" WROUGHT IRON STRAPS WELDED
Discharge Trunnion of Mill (Conical or Cylindrical)
Screen for extracting chips and oversize
AMALGAM BAFFLE ; REMOVABLE SHEET-COPPER CYLINDER (AMALGAMATED)
CHIPS & OVERSIZE TO SUITABLE RECEPTACLE
MAIN DISCHARGE-END BEARING
BINDING SCREWS FOR SCREEN
MERCURY AND BALLS OF AMALGAM
PLUG FOR REMOVING ACCUMULATED CONTENTS
TO LAUNDER
HARDINGE AMALGAMATOR
PATENT APPLIED FOR

FIG. 2*a*—DIAGRAM OF HARDINGE AMALGAMATOR

FIG. 3—TABLE PLATES AND WILFLEY TABLES, PLYMOUTH MILL

The next move was to attach a Hardinge amalgamator to one of the mills and a Plymouth amalgamator, to be described later, to the other. These have given very satisfactory service. The Hardinge amalgamator, Fig. 2, may be described as a miniature Hardinge mill which is attached to the discharge of the mill proper. It is of cast iron, and the object is to produce the same effect in amalgamation as the mill does; that is, to bring the

gold, especially that which is rusty or in coarse particles, into forceful contact with the quicksilver. The amalgamator gives the pulp a rolling action as it is discharged through it, and when it is run dry the discharge cone becomes coated with amalgam and balls of the latter form having diameters up to ¾ in. These balls materially assist in the amalgamation and at cleanup a few copper balls are put into the amalgamator for the same purpose.

After passing the Hardinge amalgamator the pulp is run over a 4-millimeter screen shown in the illustration for the purpose of removing chips and any small pebbles that may have been thrown out. Thence it runs over two silvered sluice plates, each 2½ ft. by 6 ft. on a grade of 2 in. per foot and through a launder to ten table plates (Fig. 3), each 3 ft. by 14 ft., set in pairs on a grade of 2½ in. per foot. Shallow traps are provided at the top, middle and bottom of the sluice plates and top and bottom of the table plates. The tailings from the table plates go to an elevator.

The above describes the process of primary amalgamation as carried on in one section of the mill. Practice in the other section differs slightly. Here the Hardinge mill discharge passes directly over the sluice plates and thence to a Plymouth amalgamator, Fig. 4. This amalgamator was designed and built in the Plymouth mill and has proved very successful. It is now in use at the Argonaut mill at Jackson, Col., and on one of the Natomas Consolidated gold dredges. It is a wooden box 6 ft. by 18 in. divided lengthwise into two compartments, one 12 in. and the other 6 in. wide. It receives 200 2-in. longitudinal strokes per minute, being actuated by the head motion of an Isbell vanner. The wider compartment has an iron bottom and is covered to a depth of ¼ in with quicksilver. The narrower compartment is provided with a regular amalgamating plate in the bottom. The pulp from the sluice plates passes to the wider compartment of this shaking amalgamator, where it is subjected to a rapid agitation in the quicksilver bath and then discharged over the plate in the second compartment to the table plates. This device is, in effect, a shaking amalgam trap for the recovery of the coarse gold. Before the installation of the Hardinge and Plymouth amalgamators free gold could be seen in the concentrates of the Wilfley tables, but these devices have remedied that trouble.

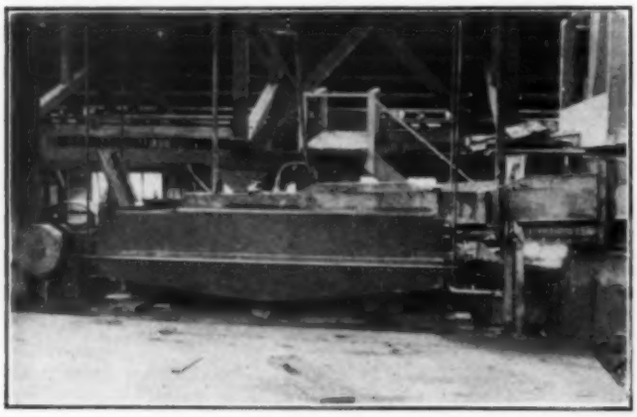

FIG. 4—PLYMOUTH AMALGAMATOR

The amalgamators, traps on the sluice plates, sluice plates and traps at the heads of the table plates are cleaned up daily. The table plates are cleaned twice a month. It is found that of the free gold recovered in the form of amalgam 53½ per cent is caught in the amalgamators and traps. Of the remaining 46½ per cent, 85 per cent, or 40 per cent of the total recovery, is caught on the sluice plates following the Hardinge mills and 6½ per cent of the total is caught on the table plates. Thus it will be seen that it is a distinct advantage with this ore to amalgamate in stages.

The amalgam from the amalgamators and traps retorts 50 to 60 per cent sponge; from the sluice plates, 35 to 45 per cent, and from the table plates, 20 to 25 per cent. The combined amalgam from all sources retorts from 42½ to 47 per cent, which is considerably higher than the 30 to 40 per cent which MacFarren gives as the average amount of sponge.

Concentration

All tailings from the table plates are run to an elevator with 15-in. belt, 26-ft. lift and a speed of 450 ft. per minute. As elevators are prone to give more or less trouble two have been installed at this plant at this point. One is run for a week, then shut down and given a thorough overhauling, while the other is used. These elevators are belt-driven to avoid any gear trouble. The boots are so set as to be readily accessible, with large doors so that if one does choke down practically all of the ore overflowed in the boot will run out by gravity when the door is opened. With these precautions no trouble has been experienced in their operation, and after eleven months of continuous work the belts show no appreciable signs of wear.

The elevator discharges to a 66-in. Callow cone, the underflow of which goes to a two-compartment Richards hindered-settling classifier. Each compartment of the classifier feeds a No. 6 Wilfley table, shown in the background of Fig. 3, that makes 245 ⅝-in. strokes per minute, producing tailings and concentrates but no middlings. The Wilfley concentrates contain about 11 per cent arsenic. They make up one-third of the tonnage product of the mill and three-fifths of its value.

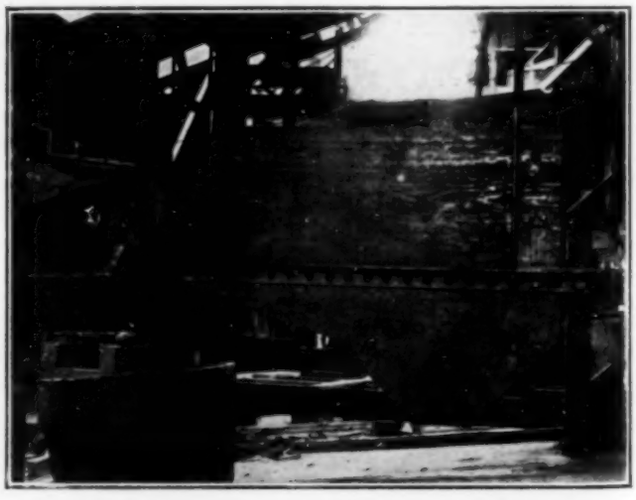

FIG. 5—CLEAN-UP JIG, PLYMOUTH MILL

The tailings of the Wilfley tables are laundered to an 8-in. elevator, which raises them 22 ft. with a speed of 450 ft. per minute to two pyramidal settlers. The underflow of each settler returns to a Hardinge mill and the overflow is run to the tailrace and wasted.

The Wilfley tables are placed on the same level as the table plates. On the next level, which is the lowest, are the vanners, thirty of Isbell design, with 6-ft. belts making 195 1-in. strokes per minute. The Isbell machine was chosen because it makes a satisfactory grade of concentrates and the cost of upkeep is less than that of most of the other designs of vanners.

The overflow of the Callow cone which receives the pulp from the first elevator is laundered to two dis-

tributing tubs. Each of these tubs distributes to three other tubs, each of which feeds four vanners, twenty-four vanners taking the Callow overflow. The overflow of the Richards classifier is laundered to two distributing tubs, each of which feeds three vanners.

All concentrates, both table and vanner, discharge to tubs from which they are shoveled and, after drying, are sacked and shipped to the smelter at Selby for treatment. Sweepings and overflow from the concentrate boxes are led to a sump and shipped. When the mill is run at its full capacity, 380 tons a day, the output of concentrates is from 5 to 7½ tons, a concentration ratio of from 50 to 75 into one.

Cleanup and Sampling

Instead of using the usual clean-up barrel and pan, the sands from the plates and the daily traps are treated in a "clean-up jig" designed at this plant and illustrated in Fig. 5. This jig has vertical sides and the general

FIG. 6--BLACK OAK MILL

appearance of a large Calumet classifier. It receives 210 2-in. longitudinal strokes per minute from an eccentric without differential motion. The sands are fed in at the top over a ¼-in. screen, from which they pass over a baffle and are subjected to the agitation caused by the eccentric, which results in a stratification so that the sands overflow at the discharge and the amalgam settles to the bottom of the jig, where it may be tapped off at the plug shown. The jig concentrate is treated in a 2-ft. clean-up pan.

Sampling is done by automatic samplers. One sample is taken of battery pulp by taking a cut the full width of the launder below the batteries. This sample is further cut down by split samplers so as to give an average of the shift's run. Tailings are similarly sampled. A sample is also taken at thirty-minute intervals from the distributor to the battery bins. These samples will usually check the pulp samples from the battery with a maximum error of 10 cents per ton. Assays of talings and concentrates are posted daily for the information of the millmen. The extraction will run 90 per cent on an ore assaying $5 per ton or better. On lower grade ore it will be a little less.

The mill is handled by two men on each shift actually engaged in operation. These are an amalgamator, who also looks after the crushing machinery and who acts as foreman on the night shifts, and a vannerman. In addition the day shift has a foreman, repairmen, amalgamator helper and concentrate sacker. Crushing is done entirely on the night shift. Detailed costs of milling are not available at present, but the management states that the total costs of mining and milling, including new construction, development, etc., are from $2.70 to $3 per ton.

The Plymouth mill was designed with the idea of treating this ore as efficiently as possible, and it has been part of this general scheme to surround the operators with such conditions as would tend to promote their efficiency. Mention has been made of the lighting system. Heat is furnished in cold weather by numerous electric heaters. As the general location hereabouts is somewhat conducive to malaria all drinking water used in the mill is filtered. There is a change room in the mill supplied with hot and cold water and, shower baths are available at the main change house at the shaft. Motors are placed, as far as possible, out of the way, and all line shafts are readily accessible from broad runways. But best of all, and a feature that cannot be commended too highly, there is not a motor, belt or gear in the mill that is not so carefully protected but that a man could only be caught in it by deliberate intent on his part.

Horsepower

As stated, a larger motor than necessary is used for the Hardinge mills, elevators and tables. In the following summary the actual horsepower used on these machines is estimated with a liberal allowance for transmission and friction losses in a rather extensive system of line shafting.

Machine	Horsepower
Crusher	35
First conveyor	10
Second conveyor	15
Third conveyor	10
Stamps (twenty-five)	85
Hardinge mills (two)	80
Plymouth amalgamator	1
Elevators (two)	10
Wilfley tables (two)	3
Vanners (thirty)	25
Total	274

This equals an actual expenditure of about 0.7 hp. per ton of ore treated. Power is purchased from the Pacific

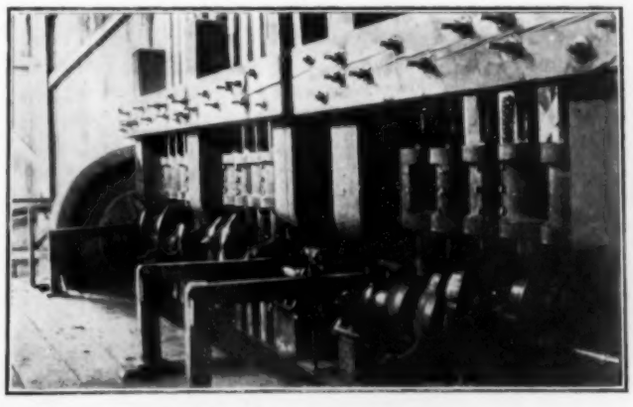

FIG. 7—CAM FLOOR BLACK OAK MILL

Gas & Electric Company at 44,000 volts, transformed at the mill and distributed at 440 volts.

Modified Practice

Under certain conditions the system described above is modified to some extent. When both Hardinge mills are used only twenty-five stamps are dropped, but if the grade of ore is low, or if a mill needs lining, one of them is cut out and all thirty stamps are dropped, three of the batteries being equipped with No. 296 Rektang

(19-mesh) screen. With the finer screen stamp duty per twenty-four hours is from 8½ to 9½ tons. This compares with 12½ to 16 tons through the 6-mesh screen according to the amount of hard quartz in the ore. Screen tests of the battery discharge through the 19-mesh screen show about the same percentage of + 30 material in the pulp as from the Hardinge mill, but that the colloids will run 21-22 per cent. From the above it appears that forty-two stamps would be required to crush direct the same amount now handled by the twenty-five stamps and the two Hardinge mills.

Concentrate treatment has always been an important question in the handling of Mother Lode ores. At present the Plymouth is shipping to Selby and treatment charges range from $17.50 to $22 per ton, according to the grade. This item in itself amounts to approximately 30 cents per ton of ore treated aside from the freight

FIG. 8—LOWER FLOOR, BLACK OAK MILL, OLIVER FILTER IN BACKGROUND

and the fact that the smelter pays for gold at the rate of only $19 per ounce. At this writing the Plymouth is operating a 200-lb. experimental plant to determine the advisability of cyaniding the concentrates. It is also considering the possibility of cyaniding the Wilfley tailings instead of returning them for regrinding.

Black Oak Mill

The ore of the Black Oak is found in fissures in the "Soulsbyville granite," a notoriously hard rock consisting of true granite and granodiorite with ribs of diorite. It is a quartz gangue containing gold with small quantities of silver. About 40 per cent of the gold occurs in the free state and the remainder is associated with pyrite, arsenopyrite and very small amounts of galena. The gold and silver are the valuable constituents of the ore, the amount of lead in the galena being too small to make its recovery profitable.

The ore is hoisted from the shaft in self-dumping skips which discharge to the mine bin from which it is discharged over a grizzly. A rough sorting for the larger chunks of waste is carried on at the grizzly. The over-size is run through a 15-in. x 10-in. Blake crusher to the bin beneath, from which the ore is loaded through rack-and-pinion gates to cars and hand-trimmed to the mill. The mill, Fig. 6, is of 100-tons capacity, timber construction, built on a hillside with a down grade from the mine bin. The mill bins are slope-bottomed and have a capacity of 200 tons, sufficient for two days' run in case there is an interruption to hoisting from the mine.

Crushing and Classifying

The ore is fed from the mill bins to four five-stamp batteries, Fig. 7, by means of Challenge feeders actuated by the middle stamp stem, lime being added at the feeders in the desired proportion. The stamps weigh 1200 lb. each and make 106 6-in. drops per minute in the order of 1-5-3-2-4. The ore is crushed in a 4½-lb. cyanide solution. Three of the batteries are fitted with No. 18 Tyler "tan-cap" screens and one with a six-mesh screen. A 75-hp. motor drives the batteries.

The battery pulp is distributed to one simplex and one duplex Dorr classifier. The coarse product of the classifiers goes to a 4-ft. x 20-ft. Power and Mining Machinery Company tube mill and the fine to a 3½-in. centrifugal pump which is chain-belted to a 5-hp. motor and discharges to a 20-ft. x 10-ft. Dorr thickener.

The tube mill crushes 60 tons per twenty-four hours making 27 r.p.m. Danish pebbles are used at the rate of 4½ lb. per ton of ore crushed. It is driven by a 75-hp. motor. Seventy per cent of the discharge will pass 200-mesh. Instead of using lead acetate to assist in the precipitation, litharge is used by feeding it into the tube mill at the rate of 1 lb. per ton of ore. It is estimated that 70 per cent of the valuable constituents of the ore is in solution when it leaves the tube mill.

The tube mill is in a closed cricuit with the Dorr classifiers. The discharge goes to a bucket elevator with 4-in. x 8-in. buckets on 12-in. centers. This elevator has a lift of 16 ft. and a speed of 450 ft. per minute, returning the pulp to the classifiers. A 5-hp. motor drives the elevator and classifiers.

Decantation and Filtration

The fines from the Dorr classifier are sent by way of the centrifugal pump to the first Dorr thickener from which they are transferred by means of a Pohle air-lift to the first of a series of three Pachuca tanks, each 10 ft. x 30 ft. The slime is continuously agitated in these three tanks, finally overflowing the third tank to a second Dorr thickener the same size as the first. Here the pulp is brought to a consistency of 70 per cent moisture (Sp. Gr. 1.32) and the overflow discharged to the collecting sump below the Oliver filter which also receives the pregnant solution from the filter.

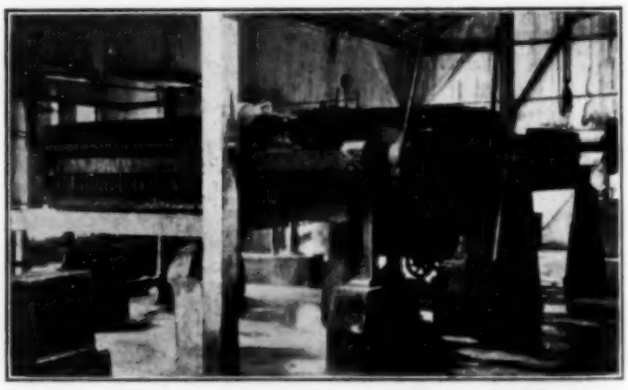

FIG. 9—SHRIVER AND MERRILL FILTER PRESSES, BLACK OAK MILL

The pulp from the second Dorr thickener goes to an Oliver continuous filter, 6 ft. x 12 ft. (Fig. 8) which makes a complete revolution in seven minutes. A 5-hp. motor drives the Dorr thickeners and Oliver filter.

Air for the Pachuca tanks and for discharging the cake from the Oliver filter is supplied under 45 lb. pressure by a 10-in. x 8-in. Ingersoll-Rand compressor working with a capacity of 100 cu. ft. of free air per minute, belted to a 25-hp. motor. Vacuum is furnished at 20 in. to 22 in. to the Oliver filter by a piston-inlet compressor working at 125 cu. ft. of free air per minute and driven by a 15-hp. motor.

The pregnant solution from the Oliver filter flows to a collecting tank of 600-gal. capacity, which, as noted, also receives the overflow of the Dorr thickener. From the collecting tank the solution is pumped by a 4½-in. x 6-in. Dorr horizontal duplex pump belted to a 5-hp. motor to a 34-frame Shriver filter press (Fig. 9), in which it is clarified. From the Shriver press the clarified solution goes to a 900-gal. tank in which the zinc dust is added and from which it is pumped to a 22-frame, 4-ft. Merrill press (Fig. 9) by a 5½-in. x 8-in. Platt triplex pump geared to a 5-hp. motor. The barren solution from the Merrill press is pumped to two 65-ton stock tanks where it is brought up to standard, 4½-lb. KCN per ton.

The zinc dust precipitate is loaded to an iron tray which is wheeled out and dried over an open fire. No acid treatment is given the precipitate, which is refined by slagging with borax and sand and melted in a No. 150 graphite crucible in an oil-fired Steele-Harvey tilting furnace.

Chemicals and Power

During the past year the consumption of chemicals per ton of ore has been as follows: Cyanide, 1.25 lb.; lime, 3.27 lb.; zinc, 1.30 lb.

All ore passing through the mill is sampled twice, once by a grab sample from each car as it is weighed and once by sampling at regular intervals at the feeder. Tailings are sampled automatically and the extraction as calculated from the head and tailing samples is checked against the actual bullion return, the two results usually agreeing within a small fraction of 1 per cent.

Power is purchased from the Sierra-San Francisco Power Company and delivered at 40,000 volts to the substation where it is stepped down for distribution at 440 volts. An average of power costs for the first two months of 1915 was 45 cents per ton of ore. Power is used as follows:

Machines.	Power.
Crusher	15 hp.
Stamps (20)	75 hp.
Tube mill	75 hp.
Centrifugal pump	5 hp.
Elevator and classifiers (2)	5 hp.
Compressor	25 hp.
Vacuum pump	15 hp.
Dorr thickeners (2) and Oliver filter.	5 hp.
Dorr pump	5 hp.
Platt pump	5 hp.
Return pump	25 hp.
Total	255 hp.

This indicates a consumption of 2.55 hp. per ton of ore treated.

Costs

An average for two years shows the following assays and extractions:

Year	Heads	Tails	Extraction
1913	$13.218	$0.574	95.58 per cent
1914	11.873	0.220	98.15 per cent

These figures are based on actual bullion recovery and tailings assays.

The following costs are given out:

Year	Tonnage	Power, supplies, etc.	Labor	Total
1913	25,853.7	$0.960	$0.620	$1.580
1914	11,518.8	1.331	0.908	2.239

The above costs include superintendence, clerical expense and all other overhead charges.

During 1914 the mine was carrying on extensive development work which limited production. On this account the mill was run at far less than normal capacity but as expenses were the same as with the full capacity there was a corresponding increase in the cost per ton. As the Black Oak was the first mill to cyanide these ores and 1913 was the first full year that it operated, it is reasonable to expect that the extraction record of 1914, when the operatives had had the benefit of some experience, will be maintained. For these reasons it is fair to judge the possibilities of this plant by its 1913 costs and 1914 extraction.

Comment

Two-stage crushing has been so universally adopted in other districts and so thoroughly discussed that there is hardly room for comment. Observations at these plants do not tend to the conclusion that it effects any saving in power but it is obvious that at such a mill as the Plymouth the form in which the pulp is discharged is a material advantage.

The Plymouth presents many innovations from a mechanical standpoint while the Black Oak was an innovation *in toto* so far as these ores are concerned.

While in general the ores may be considered similar there is sufficient difference to make a comparison difficult. One cannot but notice the difference in the power used in fine crushing and grinding, 0.43 hp. per ton in the Plymouth mill as against 1.5 hp. in the Black Oak. But the Plymouth ore is mixed with a soft slate while the Black Oak is associated with the extremely hard Soulsbyville granite which breaks much coarser in the stopes. This difference in hardness is brought out by the pebble consumption, 1.5 lb. per ton at the Plymouth against 4.5 lb. per ton at the Black Oak. Further the Hardinge mill discharges only 15-20 per cent of —200 material while the discharge of the Black Oak tube is 70 per cent of —200. It is probable also that the relative efficiencies of these two machines are a factor, as it is generally considered that a Hardinge mill consumes less power under the same conditions than a long tube.

Some comparison may be made of the relative economy of the two processes, especially with respect to the Black Oak whose detailed costs are presented. If we assume that 62½ per cent of the Plymouth ore is recovered on the plates and that the mill extraction is 90 per cent it appears that the extraction in the concentrating department is 73½ per cent. If we assume a $12 ore for the Black Oak, a recovery of 40 per cent on plates and an extraction on the concentrating machines corresponding to that of the Plymouth we should have a tailings loss of $1.91. This exceeds the corresponding loss from this source by cyaniding by $1.67 which is 9 cents more than the total costs for milling during 1913 which is the proper criterion of future service. Thus an attempt to follow the Plymouth system at the Black Oak would result in a loss per ton of $1.67 plus freight and smelter charges on concentrates and the difference in the value of the gold as paid for by the smelter, against which the only offset would be the difference in the cost of the two methods, amalgamation and concentration being accomplished at a considerably lower figure than cyaniding. Obviously cyaniding is the more economical method of treating these ores.

In the absence of detailed costs from the Plymouth a similar comparison can only be tentative. Under present conditions tailings losses are approximately 50 cents per ton, smelter charges, 30 cents and the difference in the rate of settlement for gold, say 15 cents. Freight charges are not available. If a 98 per cent extraction could be obtained so as to reduce the tailings losses by 40 cents the question would be whether the difference in milling costs would be more or less than the in-

creased saving, 40 cents, plus smelter charges, 30 cents, plus difference in payment for gold, 15 cents, plus freight on the concentrates and the cost of sacking.

From some information I have had regarding costs of treating these ores by amalgamation and concentration I am of the opinion that the present system is better adapted to the Plymouth ores even considering the greater tonnage of its plant than that of the Black Oak and the possibility that that 98 per cent extraction *might* be realized. In the absence of any data on cyaniding Mother Lode ores one cannot predict what saving could be made. I do not know about the Plymouth ore but many mines in this belt encounter graphite in sufficient amount seriously to interfere with cyaniding, which is a factor that would have to be taken into consideration.

While such a discussion is interesting from a theoretical point of view it must be borne in mind that the Plymouth mill was designed by a competent engineer and it is taken for granted that the system installed was selected as the most economical after due consideration of every phase. But it is interesting to note that there is a leaning toward a modification of the process to include cyaniding the concentrates and possibly the Wilfley tailings.

I am indebted to many officials and employees of the two companies whose operations are described, particularly Messrs. Roger Knox, superintendent; C. W. Hopkins, secretary, and F. W. Watts, mill superintendent of the Black Oak and S. R. Brown, mill superintendent of the Plymouth Consolidated.

San Francisco, Cal.

Efficiency of the Blast Furnace Operation

BY BIRGER F. BURMAN

Pure air contains besides oxygen and nitrogen about 0.04 per cent CO_2. It is also claimed that in the proportion assigned to nitrogen about 1 per cent consists of other rare inert gases such as argon, neon, krypton, zenon, helium, etc., as well as small quantities of hydrogen and water vapor. With the exception of water vapor only oxygen and nitrogen need be considered for practical purposes, and the composition of pure, dry air is therefore by many accepted to be:

	By Volume	By Weight
Oxygen	20.8 per cent	23.1 per cent
Nitrogen	79.2 per cent	76.9 per cent

As pure air is always accompanied by a certain amount of water vapor, dependent on the existing temperature and barometric pressure, the air mixture of oxygen, nitrogen and H_2O vapor, which concerns us directly, will constantly vary in composition. If pure air could be secured for practical purposes, the air mixture of oxygen and nitrogen with above composition would certainly be of maximum efficiency; and as only oxygen is of value for combustion the amount of this element as shown must give to the air mixture a 100 per cent efficiency.

Nitrogen and the other gases are not only inactive as far as combustion is concerned, but they dilute the products of combustion and absorb considerable amount of heat. However, they are not as harmful as H_2O vapor, which gas in addition must also be decomposed, thereby consuming fixed carbon according to the following reaction:

$$H_2O + C = H_2 + CO.$$

As 12-unit weights of carbon are involved, the consumption of fixed carbon will be 0.67 to every unit weight of H_2O vapor reduced. This carbon is a dead loss, but that is not all. The reaction cannot exist without addition of more heat. As it stands the loss is 1606 pound-calories per pound of H_2O vapor or 2408 pound-calories per pound of carbon involved. This heat is partly furnished by the sensible heat in the H_2O vapor and in the hot carbon, but even under favorable conditions it is not sufficient and extra carbon has to be utilized. In other words, the presence of water vapor lowers the temperature of combustion as it robs the pure-air combustion of a certain amount of heat.

The amount of H_2O vapor present in the blast is small, figured per cubic foot; but when millions are used in a day, the weight of water pumped into the blast furnace is enormous. It therefore becomes of supreme importance to endeavor to cut down the moisture content to the absolute minimum not only in order to save fuel, but also to secure a uniform composition of the blast, thus aiding the regular run of the operation.

If the air is at 60 deg. Fahr. dry and 47 deg. Fahr. wet* the relative humidity is 35 per cent and the weight of H_2O vapor per cubic foot of air mixture will be 0.000289 lb. At another time the respective temperatures are + 0 deg. Fahr. and — 2 deg. Fahr., giving also a 35 per cent humidity, but the weight of H_2O vapor will now be only 0.000024 lb. If during twenty-four hours a blast furnace receives 60,000,000 cu. ft. of blast, the water pumped in each case will be 17340 lb. and 1440 lb. Of course, in case of the colder blast only about 53,069,000 cu. ft. had to be pumped in order to make it equal the 60,000,000 at the higher temperature, but this makes the comparison still more unfavorable for the warmer and more humid blast, as the drier air will contain only 1274 lb. of water.

By cooling the air the H_2O vapor can be eliminated, but it is an expensive operation. While a dry-blast plant ought to be built at every blast-furnace plant the cost is by many considered prohibitive. A partial improvement may be secured by carrying the blast intake to the outside of the blowing engine room, thus pumping air of lower temperatures at little or no cost—if the first cost of building the intake be excepted. Water-cooling also forms another kind of less expensive but at the same time less satisfactory arrangement as far as results are concerned when compared with the dry-blast plant.

Volumes vary constantly, dependent on the temperatures and pressures to which they are subjected. One cubic foot of air mixture (containing no moisture) at zero will at a higher temperature, with the pressure remaining the same, take a larger volume, of which 1 cu. ft. must weigh less. The percentage of oxygen has not changed; consequently the amount of this element must also become less per cubic foot at the higher temperature. If now H_2O vapor is added, the weight of the oxygen in the cubic foot of air mixture will be somewhat less in the former case but much more so in the latter case, due to the increased amount of H_2O vapor at higher temperatures.

As oxygen is the only desirable element for combustion it is important to deliver to the blast furnace not only pure, dry air but also a regular amount of same. If, for instance, I was delivering 40,000 cu. ft. per min. under any and all conditions, I would constantly vary the amount of oxygen, which variations in case of no refrigeration would be still more intensified. The result would be difficulties in keeping up a regular run of the blast furnace with accompanying losses.

The only proper thing to do is to reverse these conditions and deliver to the blast furnace a constant amount of pure, dry air under any and all conditions, which, of course, will be equivalent to a constantly variable volume of air mixture per unit of time. At the same time the amount of H_2O vapor should be cut down to the minimum.

*At a bar. pressure of 29".

It will not be possible to deliver the proper amount of oxygen without a table giving the number of revolutions per minute at any desired temperature and relative humidity. Such a table is a necessary guide to the blowing-room foreman.

Before such a table can be worked out the displacement of the blowing cylinder must be ascertained. This should be carefully done, and after all measurements have been established the following calculations will determine it:

V = Volume of air cylinder, empty, including the two clearances and all the voids at the ports, ...cubic feet.

V_1 = Volume of the two clearances and all the voids at the ports minus volume of piston rod equal to the depth of one clearance, ...cubic feet.

V_2 = Volume of one piston, ...cubic feet.

V_3 = Volume of one piston rod of the length of the stroke plus the depth of two clearances, ...cubic feet.

V_4 = Volume of the open space per revolution:

$= 2V - (2V_1 + V_3)$ cubic feet.

In degrees Fahrenheit:

Dry temperature of air mixture, going into the cylinder .....t

Dry temperature of blast, leaving the cylinder ..... t_1.

In inches of mercury:

Barometric pressure.....P.

Blast pressure—absolute (gage + barometer) ..... P_2.

V_5 = Volume of air mixture (blast) per revolution at any time for one air cylinder:

$$= V_4 - \left(2V_1 \times \frac{459.4 + t}{459.4 + t_1} \times \frac{P_2}{P}\right) \text{ cubic feet.}$$

This formula may be considered close enough for practical purposes and represents the net displacement at any time. It can readily be seen that the volume of air mixture is dependent on a number of factors, and as the volume of the air, which is trapped in the space V_1, also is undergoing constant changes, the chances of success in working out a standard table of blast regulation, that would be at the same time correct and practicable, is very slight. However, as it would neither be practicable to have a separate table made out for the displacement, covering any and all conditions, a fairly accurate figure for volume V_2, to be used only as a basis for the Table of Blast Regulation, may be had by adopting the following analysis:

The rise in temperature of the blast during its passage through the blowing engine is considerable. Observations made by the author have given averages as high as 150 deg. Fahr. The blast pressure, we know, will vary anywhere from 8 to 20 lb. per square inch. Let us therefore assume that one atmosphere is the average compression; however, any plant probably has the average for a considerable length of time and in such a case this would be the figure to use. When the gage pressure is one atmosphere, the absolute pressure will be about two, consequently when the delivery port is closed and the piston starts on its return trip, the air mixture, trapped in space V_1, will be subjected to a contraction in volume of approximately 0.75, due to the temperature, and an expansion of about 2, due to the pressure, making a total expansion of about 1.5. The formula will therefore be $V_4 - 3V_1$, which, in the absence of records for temperatures and pressures, may be adopted.

Having established the displacement per revolution, the next step will be to assume a standard for the weight of pure, dry air to be delivered per minute during any and all conditions.

As the barometric pressure constantly varies, and it is not practicable and indeed not necessary either to have a table for every change; and, furthermore, as the barometer usually stands around 29 in., there need be only two tables in the blowing room: one, covering pressures between 28.5 in. and 29.4999 in., called the 29-in. table, and another table, taking in pressures between 29.5 in. and 30.4999 in., called the 30-in. table.

The table may be worked out for any range of temperatures but it will be found that 0 deg. to 100 deg. Fahr. is a very suitable one. Of course, in colder climates, the temperature will go lower than 0 deg. Fahr., just as in warmer countries it might rise above 100 deg. Fahr. In such a case the range should be extended to include such temperatures.

It is not necessary to include every per cent vapor saturation, 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 per cent answering all practical purposes.

EXAMPLE

Work out a table of blast regulation for 29-in. barometer pressure when: The blowing cylinder is 84 in. in diameter × 60-in. stroke and 3000 lb. is the standard for weight of pure, dry air to be delivered per minute under any and all conditions.

Blowing cylinder displacement:

V = 229.5 cu. ft.
V_1 = 7 cu. ft.
V_2 = 30 cu. ft.
V_3 = 2.3 cu. ft.
V_4 = 396.7 cu. ft.
V_5 = 396.7 — (3 × 7) = 375.7 cu. ft.

Net displacement is therefore 375.7 cu. ft.

In the formulas below:

t denotes dry temperature of air mixture in degrees Fahrenheit.
P denotes barometric pressure in inches of mercury.
P_1 denotes vapor pressure in inches of mercury.
P_2 denotes air pressure in inches of mercury.

"Standard conditions" represent 32 deg. Fahr. and 29.9212 in. barometric pressure.

Weight of dry air in 1 cu. ft. of any air mixture is

$$0.080728 \times \frac{459.4 + 32}{459.4 + t} \times \frac{P_2}{P} \times \frac{P}{29.9212} = \frac{1.32581 \times P_2}{459.4 + t} \text{ pounds.}$$

In case of no moisture being present the factor $\frac{P_2}{P}$ disappears and the formula will give $\frac{1.32581 \times P}{459.4 + t}$ pounds.

Applying these formulas to our case for 0 deg. Fahr. the weight of dry air in 365 cu. ft. of air mixture with no moisture present (relative humidity = 0 per cent) will be:

$$365\left(\frac{1.32581 \times 29}{459.4}\right) = 30.54782 \text{ lb.}$$

When the relative humidity is 100 per cent the vapor pressure P_1 is 0.0383 in., the air pressure P_2 is 28.9617 in., the barometric pressure P is 29 in., and the weight of dry air in 365 cu. ft. of air mixture will be:

$$365\left(\frac{1.32581 \times 28.9617}{459.4}\right) = 30.50748 \text{ lb.}$$

By dividing the respective weights into 3000 the quotient will be the revolutions per minute necessary to deliver the proper volume of dry air; thus for 0 per cent humidity 98.21 r.p.m. and for 100 per cent humidity 98.34 r.p.m.

The difference 98.34 — 98.21 = 0.12 may be equally distributed on the miscellaneous relative humidities and the revolutions per minute will therefore be:

Relative Humidity Per Cent	R.P.M.
0	98.21
10	98.22
20	98.24
30	98.25
40	98.26
50	98.28
60	98.29
70	98.30
80	98.32
90	98.33
100	98.34

The table will now be completed for 0 deg. by inserting these figures for revolutions per minute.

Applying again the formulas to our case for 100 deg. Fahr., the weight of dry air in 365 cu. ft. of air mixture with no moisture present (relative humidity = 0 per cent) will be:

In the following calculations the figure 365 has been used so as not to change calculations that had already been made. This will not alter the methods of calculations, although it is incorrect for the example itself.

$$365\left(\frac{1.32581 \times 29}{559.4}\right) = 25.08706 \text{ lb.}$$

When the relative humidity is 100 per cent the vapor pressure P_1 is 1.916 in., the air pressure P_2 is 27.084 in., the barometric pressure P is 29 in. and the weight of dry air in 365 cu. ft. of air mixture will be:

$$365\left(\frac{1.32581 \times 27.084}{559.4}\right) = 23.42958 \text{ lb.}$$

By dividing the respective weights into 3000 the quotient will be the revolutions per minute necessary to deliver the proper volume of dry air; thus for 0 per cent humidity 119.58 r.p.m. and for 100 per cent humidity 128.04 r.p.m.

The difference $128.04 - 119.58 = 8.46$ may in this case also be equally distributed on the miscellaneous relative humidities and the revolutions per minute will therefore be:

Relative Humidity Per Cent	R.P.M.
0	119.58
10	120.43
20	121.28
30	122.12
40	122.97
50	123.82
60	124.66
70	125.51
80	126.35
90	127.20
100	128.04

Complete the table for 100 deg. Fahr. by inserting above figures.

Having the two extremes recorded, the next step will be to complete calculations for each humidity separately. For instance, select the 100 per cent column and divide the difference $128.04 - 98.34 = 29.70$ into ten equal parts of 2.97 each. Complete the column for every tenth degree, which for 10 deg. Fahr. will give $98.34 + 2.97 = 101.31$, for 20 deg. Fahr. = 104.28, etc., until the revolutions per minute for 90 deg. Fahr. has been recorded. Thereafter do likewise for all temperatures between 0 deg. and 10 deg., 10 deg. and 20 deg., 20 deg. and 30 deg., etc., until the entire 100 per cent column has been completed. The other columns are figured out in a similar way.

It may be inconvenient to give the standard for dry air blown per minute in pounds, but this may easily be overcome by selecting a certain figure for the volume in cubic feet blown per minute at a certain temperature and relative humidity, and calculate the weight of dry air in this volume.

Example: What is the standard weight when I want to blow the equivalence of dry air in 40,000 cu. ft. of air mixture at 50 deg. Fahr. and 50 per cent vapor saturation?

The vapor pressure for 50 deg. Fahr. and 100 per cent saturation is 0.360 in., the vapor pressure for 50 deg. Fahr. and 50 per cent saturation = $0.360 \times 0.50 = 0.180$ in., the air pressure for 50 deg. Fahr. and 50 per cent saturation is 28.82 in., all for a barometric pressure here assumed to be 29 in.

The weight of dry air in the 40,000 cu. ft. of air mixture is $40{,}000\left(\frac{1.32581 \times 28.82}{509.4}\right) = 3000$ lb. and the standard will therefore be 3000 lb. per minute, or pounds per 100 lb. of pig iron (see below).

Two 29-in. and 30-in. tables as described are an absolute necessity in any blowing room, even though they may not give entirely correct figures for the revolutions per minute due to causes over which there is no control. Generally speaking, the figures give good practical results. However, there are other factors that interfere with correct results even should T blow the right number of revolutions. It is therefore important to eliminate, if possible, such disturbing elements of which the following may be the most important:

1. Leakages in the air cylinders, valves, stoves, cold and hot blast mains. These can be overcome, and the stoppage of all such leaks should be the first work in the line of improvements.

2. Bad conditions of the blowing engine itself. This can also be overcome by frequently using the indicator, which is necessary in order to keep the valves set right.

3. Disturbances in the blast furnace, causing sudden differences in pressure of the blast.

The air mixture may enter the blowing cylinders under the following conditions:

1. As dry blast, when refrigeration has been carried on to the practical limit. In this case both the temperature and pressure will be almost constant with humidity practically nil. The displacement will likewise be a near constant, wherefore the number of revolutions must, as a matter of course, vary little or nothing. There will under such conditions be no need of any guiding "Table of Blast Regulation."

2. As partially dried blast, when the air mixture is more or less cooled, either artificially or by means of carrying the blast intakes to the outside of the blowing engine room. The manner of taking the temperatures will be different. In the former case provisions must be made in the air line close to the intakes of the blowing cylinders for the reading of the two thermometers. No slinging is required as the air current is swift enough. The dry bulb thermometer may be stationary, but the wet bulb should be so placed that the muslin can be dipped in the water, which must be pure and clean. Even a wick attached to the wet bulb and placed in a bottle of pure, clean water will in this case answer the purpose. This has the additional advantage of making the wet bulb also stationary. When the blast intake is carried to the outside of the building a similar wick arrangement for the wet bulb may do, placed either as above or at the entrance of the intake.

3. As natural air, taken directly from the blowing engine room. In this case sling psychrometer must be used and it is strongly recommended that the type used by the Weather Bureau be selected. In this the two thermometers are mounted in a frame, whirled around by means of shafting and miter gearing, the whole being encased, thus insuring the safety of the thermometers.

REPORT NO.

During the day of ON BLAST BLOWN INTO BLAST FURNACE NO.

Time	TEMPERATURE, DEG. F.						PRESSURES					TOTAL NUMBER OF REVOLUTIONS BLOWN BY ENGINE		Relative Humidity, Per Cent
	AIR GOING INTO THE BLOWING ENGINES			BLAST			INCHES OF MERCURY			POUNDS PER SQ. IN. BLAST				
	Dry	Wet	Diff.	Leaving Blowing Engines	At the Entrance of Stoves	At the Blast Furnace	Barometer	Vapor	Air	In the Blowing Room	At the Blast Furnace	No.	No.	
6- 7														
7- 8														
8- 9														
9-10														
10-11														
11-12														
12- 1														
1- 2														
2- 3														
3- 4														
4- 5														
5- 6														
6- 7														
7- 8														
8- 9														
9-10														
10-11														
11-12														
12- 1														
1- 2														
2- 3														
3- 4														
4- 5														
5- 6														
Total and av.														

NOTE:
Vapor pressure is determined by means of Weather Bureau's Psychrometric Tables and air pressure = difference between the barometric and vapor pressures.
Relative humidity is given directly in the Weather Bureau's Psychrometric Tables, when the Depression of wet-bulb thermometer as shown in third column by "Diff." is known.
When using these records for blast furnace tests of several days' duration, averages must be taken on all reports combined. Do not establish average on averages.

TABLE OF BLAST REGULATION

FOR BAROMETRIC PRESSURE ..... INCHES OF MERCURY

Standard for weight of dry air blown per minute, pounds
Displacement of blowing cylinder per revolution, cubic feet
R.p.m. as shown give the same weight of dry air

Figures, inserted, are for exhibition only. They are based on a standard supply of 3000 pounds of dry air delivered per minute by blowing cylinders of 365 cu. ft. displacement.

This table has been completed for 100 per cent relative humidity only and for every 10 deg. of the other humidities; this has been done in order to show methods of working it out.

Barometric pressure = 29 in.

Working barometric pressure = 28.5 in. to 29.4449 in.

	Relative Humidity										
Dry Temp. Deg. F.	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
	r.p.m.	r.p.m.	r.p.m.	r.p.m.	r.p.m.	r.p.m.	r.p.m.	r.p.m.	r.p.m.	r.p.m.	r.p.m.
0	98.21	98.22	98.24	98.25	98.26	98.28	98.29	98.30	98.32	98.33	98.34
1											98.64
2											98.94
3											99.23
4											99.53
5											99.83
6											100.12
7											100.42
8											100.72
9											101.01
10	100.35	100.44	100.54	100.64	100.73	100.83	100.93	101.02	101.12	101.22	101.31
11											101.61
12											101.90
13											102.20
14											102.50
15											102.79
16											103.09
17											103.39
18											103.68
19											103.98
20	102.49	102.65	102.84	103.03	103.20	103.39	103.57	103.74	103.92	104.11	104.28
21											104.57
22											104.87
23											105.17
24											105.47
25											105.76
26											106.05
27											106.35
28											106.65
29											106.95
30	104.62	104.87	105.15	105.41	105.67	105.94	106.20	106.46	106.72	107.00	107.25
80	115.30	115.94	116.68	117.34	118.03	118.72	119.38	120.07	120.75	121.42	122.10
81											122.39
82											122.69
83											122.99
84											123.29
85											123.59
86											123.89
87											124.18
88											124.48
89											124.78
90	117.44	118.16	118.98	119.73	120.50	121.27	122.02	122.79	123.55	124.31	125.07
91											125.37
92											125.67
93											125.96
94											126.26
95											126.56
96											126.86
97											127.15
98											127.45
99											127.75
100	119.58	120.43	121.28	122.12	122.97	123.82	124.66	125.51	126.35	127.20	128.04

When refrigeration is made on the compressed air mixture either the second or third condition may take place. The manner of recording the temperatures will be accordingly.

Temperature readings need not be taken oftener than once an hour. However, it is important, that they are made on regular intervals, and it is a good policy to always do it on the hour.

There may be other methods of determining the amount of H_2O vapor in the atmospheric air as for instance by means of sulphuric acid, but, while this is the most correct one, it is hardly a practical method for continuous observations.

When the temperatures are known, the vapor pressure and relative humidity are determined by means of psychrometric tables, of which the one prepared by Prof. C. F. Marvin of the U. S. Weather Bureau is very complete.

By carefully conducting the operations in the blowing room it is possible to furnish a blast of more uniform quality. But this quality must be measured with some standard; otherwise I do not know its value. As was previously stated a certain air would be 100 per cent efficient if no moisture was present, because it would then contain the maximum amount of oxygen. Consequently this is the standard I need. But the volume must likewise at the same time be given. Therefore, while any convenient figure may be chosen, the air at "standard conditions" is the most logical. The weight of 1 cu. ft. of pure, dry air is then 0.080728 lb., but as this is too small a quantity 1000 cu. ft. may be more suitable. The standard will consequently be the weight of 1000 cu. ft. of pure, dry air at 32 deg. Fahr. and 29.9212 in. barometric pressure. This weight is 80.728 lb. If the air mixture, used at any time, is converted into volume at "standard conditions," the weight of pure, dry air in 1000 cu. ft. of this air mixture, multiplied by 100 and divided by 80.728, will give the air efficiency of the blast.

It has been shown above that the "Table of Blast Regulation" must be based on a standard weight of pure, dry air per minute. Of course, this standard may be assumed to correspond with a certain weight of pig iron produced. If, for instance, the standard in question is 3000 lb. per minute and the blast furnace is expected to turn out, say, 700 lb. of pig iron during the same unit of time, the standard for dry air per 100 lb. of pig iron would be 428.6 lb. Variations from this figure would in a certain measure indicate the uniformity of operations in the blowing room and will give the blast efficiency itself. Suppose 460 lb. of dry air had been blown per 100 lb. of pig iron, the blast efficiency would be $100 - \left(\frac{(460 - 428.6)\,100}{428.6}\right) = 92.67$ per cent.

When all the information is on hand calculations should be made on a certain small unit, as for instance, 1000 lb. of pig iron produced. The figures will otherwise be too bulky.

CALCULATIONS TO DETERMINE THE VALUE OF BLAST PRODUCTION

Determine first the time for which calculations shall be made. Assume this to be twenty-four hours.

The displacement of the air cylinder will next be considered and figured out as previously shown. In the formula

$$V_s - \left(2V_1 \times \frac{459.4 + t}{459.4 + t_1} \times \frac{P_2}{P}\right)$$

t, t_1, P and P_2 are the average figures for the time in question and V_s will give the result, which is the volume at existing conditions.

In degrees Fahrenheit:

t denotes dry temperature of air mixture, entering the blowing cylinders.

t_1 denotes dry temperature of air mixture, leaving the blowing cylinders.

t_2 denotes dry temperature of air mixture at entrance of stoves.

t_3 denotes dry temperature of air mixture at the blast furnace.

t_2 and t_3 are to be used for heat in the blast at these temperatures in connection with stove tests only.

In inches of mercury:

P denotes average barometric pressure.

P_1 denotes average vapor pressure (as given by the weather bureau's psychrometric tables).

P_2 denotes average air pressure and equals $P - P_1$.

P_3 denotes average absolute pressure of blast, leaving the blowing cylinders, and equals $P +$ gage pressure.

"Total pig" denotes total weight in pounds of pig iron, produced during the twenty-four hours.

$$\text{"Pig"} = \frac{\text{"total pig"}}{100}.$$

"Total revolutions" denotes total revolutions blown during the twenty-four hours.

"Total volume" denotes total volume of air mixture, blown during the twenty-four hours as per conditions V_s and = "total revolutions" $\times$ V_s cubic feet.

A. Volume of air mixture per 100 lb. of pig iron, produced $= \frac{\text{"total volume"}}{\text{"pig"}}$ cubic feet.

B. Weight of dry air in this air mixture

$$= A\left(\frac{1.32581 \times P_2}{459.4 + t}\right) \text{lb.}$$

C. Weight of H_2O vapor in this air mixture

$$= A\left(0.080728 \times \frac{459.4 + 32}{459.4 + t} \times \frac{P_1}{P} \times \frac{P}{29.9212}\right) 0.622.$$

$$= A\left(\frac{0.82465 \times P_1}{459.4 + t}\right) \text{lb.}$$

D. Weight of air mixture (blast) $= B + C$ lb.

At standard condition (32 deg. Fahr. and 29.9212-in. barometric pressure):

E. Volume of air mixture (blast)

$$= A \times \frac{491.4}{459.4 + t} \times \frac{P}{29.9212} \text{cu. ft.}$$

F. Volume of vapor in the air mixture $= \frac{16C}{0.81}$ cu. ft.

G. Volume of dry air in the air mixture $= E - F$ cu. ft.

In per cent the air mixture contains:

H. Vapor $= 100F \div E$ volume per cent.

I. Dry air $= 100 - H$ volume per cent.

K. Number of 1000 cu. ft. in the blast at standard conditions $= \frac{E}{1000}$.

L. Weight of dry air in the blast per 1000 cu. ft. at standard conditions $= \frac{B}{K}$ lb.

M. Air efficiency of the blast $= \frac{L}{0.80728}$ per cent.

N. Weight of water pumped into the blast furnace during the twenty-four hours $= C \times$ "pig" lb.

O. Heat in the air mixture, when entering the blowing cylinders (convert t deg. Fahr. into T deg. C.):

$G(0.0189T + 0.0000017T^2)$ pound calories.

$F(0.021\ T + 0.000009\ T^2)$ pound calories.

Total (————) pound calories.

Q. Heat in the blast when leaving the blowing cylinders (convert t_1 deg. Fahr. into T_1 deg. C.):

$G(0.0189T_1 + 0.0000017T_1^3)$ pound calories.
$F(0.021\ T_1 + 0.000009\ T_1^3)$ pound calories.
Total (————) pound calories.

R. Heat in the blast at entrance of stoves (convert t_2 deg. Fahr. into T_2 deg. C., and use only in connection with stove tests):

$G(0.0189T_2 + 0.0000017T_2^3)$ pound calories.
$F(0.021\ T_2 + 0.000009\ T_2^3)$ pound calories.
Total (————) pound calories.

S. Heat in the blast at entrance of the blast furnace (convert t_3 deg. Fahr. into T_3 deg. C. and use only in connection with stove tests):

$G(0.0189T_3 + 0.0000017T_3^3)$ pound calories.
$F(0.021\ T_3 + 0.000009\ T_3^3)$ pound calories.
Total (————) pound calories.

To be Used Only in Connection with Blast Efficiency	Heat in Pound Calories	In Per Cent of Total Heat Q
Heat furnished by the atmosphere $= O$	.....	.....
Heat furnished by the blowing engines $= Q - O$	.....	.....
Total	.....	100.00

To be Used Only in Connection with Stove Tests and Blast Furnace Efficiency:	Heat in Pound Calories	In Per Cent of Total Heat S
Heat furnished by the atmosphere $= O$	.....	.....
Heat furnished by the blowing engines $= Q - O$	.....	.....
Heat furnished by the stoves $= S - R$	.....	.....
Heat lost in transfer between blowing engines and stoves $= R - Q$	.....	.....
Total	.....	100.00

U. Standard weight of dry air per 100 lb. of pig iron, produced, assumed to be.....Pounds

W. Dry air delivered in excess $= B - U$ pounds.

Y. Blast efficiency $= 100 - \left(\frac{100W}{U}\right)$ per cent.

Technical Society Meetings and Lectures at the National Exposition of Chemical Industries

The following program is complete to date for America's first National Exposition of Chemical Industries, which opens in Grand Central Palace, New York City, on Monday, Sept. 20. The managers, Messrs. Nagelvoort and Roth, working with the co-operation of the International Exhibition Company, deserve a very great deal of credit for this diversified and interesting program, and also for the equally fine motion-picture program. Credit is given by the managers to all who have assisted in the endeavor to make the exhibition a success, especially the advisory committee and the Bureau of Commercial Economics of Washington, through their assistance in securing speakers and their kindness is loaning films. The program follows:

Monday, Sept. 20

Opening day. The exposition will be formally opened by a member of the Cabinet from Washington.

Tuesday, Sept. 21

2 p. m.—HOWARD GROSS, president Tariff Commission League, "Tariff Question," followed by discussion.

8 p. m.—Meeting the New York Section of American Electrochemical Society, under whose auspices the following papers will be given:

Introductory remarks by the chairman, Dr. COLIN G. FINK.

D. T. PIERCE, Barber Asphalt Co., "Asphalt and the Brownian Movements of the Colloids of Trinidad Asphalt" (an illustrated lecture).

LINN BRADLEY, the Research Corporation, "Solution of Smoke, Dust and Fume Nuisance by Electrical Precipitation."

HARRINGTON EMERSON, the Emerson Co., "Efficiency in the Conservation of our Natural Resources."

Wednesday, Sept. 22

2 p. m.—FREDERICK W. KEOUGH, National Association of Manufacturers, "Accident Prevention in the Chemical Industries."

WELDING RING, President American Exporters' Association, "Transportation and Shipping Facilities with Foreign Countries."

J. L. LIGHTNER, Hershey Chocolate Co., "The Manufacture of Chocolate."

8 p. m.—THOS. H. NORTON, Department of Commerce, "Foreign Markets for American Chemicals."

I. F. STONE, President National Aniline & Chemical Co., "The Aniline Dye Situation."

Thursday, Sept. 23

2 p. m.—Meeting of the American Paper & Pulp Association (Technical Section), under whose auspices the following papers have been promised:

Welcoming address by President FRANK L. MOORE.

D. L. BELLINGER, "Some Experiments in Refining Groundwood Slivers."

F. G. WHEELER, "A Method of Determining the Current Capacity of a Cell in an Electrolytic Bleach Plant."

MAX CLINE, "The Possibilities of Accurate Determinations of Groundwood in Papers."

The following lectures will also be given on this day:

2 p. m.—J. L. TAYLOR, Bureau of Explosives, "Explosives."

H. A. HUSTON, German Kali Works, "Potash."

G. B. HECKEL, New Jersey Zinc Co., "Paint."

ROBT. L. FRINK, president Frink Pyrometer Co., "The Relation of Chemistry and Mechanical Manipulation to the Evolution of the Glass Industry."

8 p. m.—CHARLES V. BACON, consulting chemist, "Manufacture and Uses of Vegetable Oils."

GEORGE FRANK LORD, DuPont DeNemours Powder Co., "Chemical Effect of Dynamiting the Soil."

PERCY WILSON, secretary Association American Portland Cement Manufacturers, "The History of Cement."

In the evening a smoker has also been arranged by the Chemists' Club, to be held at its clubhouse, 50 East Forty-first Street, for visiting chemists:

Friday, Sept. 24

2 p. m.—W. D. COOLIDGE, General Electric Co., "The 'X-Ray.'"

PHILLIP SHARPLES, Barrett Manufacturing Co., "The Development of Refined Tars for Use in Road Construction and Maintenance."

8 p. m.—Joint meetings of the New York Section American Chemical Society and the American Institute of Chemical Engineers, under whose auspices the following lectures will be given:

S. P. SADTLER, S. P. Sadtler & Sons, "Some American Contributions to Industrial Chemistry."

L. H. BAEKELAND, "Chemical Industry."

Saturday, Sept. 25

2 p. m.—RAYMOND F. BACON, director Mellon Institute, "Research and Progress in American Manufacturing."

For Saturday evening Dr. Thomas H. Norton has promised a paper on the results of some special work which he has done in the past two years, and which is hoped to have far-reaching consequences.

The Open Hearth Versus the Electric Furnace in the Manufacture of Commercial Steels

BY SIDNEY CORNELL

There has been a great deal of discussion lately about the cost of making steel in the electric furnace in competition with the open-hearth furnace, and recently the assertion has been made that the electric furnace can compete with the open hearth in the manufacture of commercial steels on a large scale.

The electric furnace has successfully competed in quality and in cost with the crucible process, and in many instances can produce steel at a cost less than in the small converter or Tropenas process, and is being used for making small and special castings at a very good showing in cost. The assertion that the electric furnace can do all that the modern open-hearth furnace can do in large and organized plants, and on commercial steels, is open to doubt, and the following analysis of the facts may be of value in clearing up the situation. The matter must be considered from a commercial standpoint, and for the manufacture of steel for rails, structural shapes, merchant bar, etc., the problem is nothing more than a balance of detailed costs and investment. In order to do this the following table has been compiled from data from a year's operation of a large open-hearth plant in a well-known steel company, and compared with what is claimed to be practice obtainable in an electric furnace plant of the same capacity.

The following comparison is made from records for an open-hearth plant consisting of 80-ton furnaces, having a production of about 200 tons of ingots per day for each furnace, and compared with a 20-ton electric furnace having approximately the same capacity per day. This comparison must be made assuming that an electric furnace plant of some ten furnaces is substituted for a plant of open-hearth furnaces containing ten furnaces, each plant being equipped with the necessary auxiliary apparatus, mixers, scrap yards, cinder ladles, ingot equipment, tracks, etc., etc.

The cost of a modern open-hearth plant with 80-ton units, is approximately $275,000 per furnace, including all auxiliary equipment, building, etc. The cost of a 20-ton electric furnace of the most advanced type is estimated at $500,000 per unit, and including the necessary electrical equipment. In connection with the electric furnace it is assumed that blast-furnace gas would be converted into electricity, and that modern practice cleans all blast-furnace gas, thus making the gas engine and equipment chargeable to the electric-furnace equipment, but not the gas-cleaning plant.

Table I is a tabulation of the materials necessary to make a ton of steel, and whether the electric or the open-hearth furnace is used or not, the quantity of raw materials is approximately the same. It is argued that the electric furnace can use inferior materials. Inferior materials necessarily are not in the most advantageous shape to handle, and often are more bulky than those of better quality, so that although in the auxiliary charge the electric furnace might use a slightly smaller quantity this would be offset in the more bulky principal materials, and accordingly more troublesome to handle.

The electric furnace will consume the same raw materials in the making of a ton of steel, the molds used will be the same, and the only credit will then be refractories, and producer gas, from the tabulation of Table I.

In Table I the cost of rebuilding is included in the refractories cost, which is given totaled for the electric furnace, and the cost of power is taken at a low figure $0.007 per kw.-hr. In a commercial plant such as is under consideration, the labor distribution for the handling of the quantity of materials necessary to make each ton of steel will be the same for either type of furnace, and in this work organization of a force is as imperative for a plant of electric furnaces as for an open-hearth plant. Further, an electric-furnace plant, being part of a steel works, would have to bear its share of the non-producing departments, and accordingly Table II applies for both purposes.

Table III (Labor in Repairs) will also hold good as much for an electric-furnace plant as for an open-hearth plant, because as may be noted, the large portion of the charges are not for the furnace proper, and the furnace proper is a comparatively small item.

Table I—Materials Charged per Ton of Steel

Material	Pounds per Ton of Steel	Rate Cost per Pound	Cost per Ton Steel Open Hearth	Cost per Ton Steel Electric Furnace
Hot metal	872	$0.005	$4.360	$4.360
Cold pig	376	0.005	1.880	1.880
Chills	17	0.008	0.136	0.136
Moulds	15	0.010	0.150	0.150
Castings (iron scrap)	5	0.008	0.040	0.040
Pit scrap	64	0.007	0.448	0.448
Ingot butts	46	0.007	0.322	0.322
Turnings	41	0.005	0.205	0.205
Sheet scrap	99	0.006	0.594	0.594
Miscellaneous steel scrap	852	0.005	4.260	4.260
Limestone	119	0.0005	0.059	0.059
Ferro-manganese	16	0.020	0.320	0.320
Ferro-silicon	0.5	0.010	0.005	0.005
Iron ore	108	0.0012	0.129	0.129
Fluor spar	4	0.0009	0.003	0.003
Coal	4	0.0009	0.003	0.003
Aluminum	0.25	0.2000	0.050	0.050
New moulds (40 lb. per ton)	25	0.010	0.250	0.250
Cupola relining (Dolomite)	.....	.....	0.010	
Calcined dolomite	105	0.0011	0.123	
Magnesite	3.5	0.010	0.035	
Chrome ore	1	0.009	0.009	0.240
Clay	5	0.0006	0.003	(total)
Loam	9	0.0005	0.004	
Coke	16	0.0014	0.022	
Ladle brick	0.9	0.010	0.009	0.009
Stoppers	0.012	0.010	0.0012	0.0012
Sleeves	0.214	0.028	0.0061	0.0061
Nozzles	0.021	0.010	0.0021	0.0021
Rebuilding	.....	.....	0.1400	.....
Producer gas	5250. cf.	10c M. cf.	0.5250	.....
Electric power	605 kw.-hours	0.007 kw.-hour	.....	4.220
Total			$14.1034	$17.6924

Table II—Labor Cost in Making Steel

Function	Item	Cost per Ton of Steel
General	General works	$0.092
	Steam	0.003
	Water	0.007
	Electric light and power (for cranes, etc.)	0.012
	Yard switching	0.045
	Shops	0.065
Producing labor	Superintendents and foremen	0.009
	Clerks, Timekeepers and Weightmasters	0.014
Stocking	Unloading and handling from cars	0.042
	Filling boxes from bins	0.015
	Cranemen, etc., handling boxes	0.019
	Narrow-gage engineers, etc	0.013
Charging	Charging machine men	0.012
	Pull-ups and cranemen	0.009
	Metal mixed labor	0.020
Melting	Melting and gas tending (or electrodes)	0.170
	Lining hot metal ladles	0.006
	Bottom making	0.017
Casting	Ladle lining and stopper setting	0.040
	Mould handling	0.012
	Scrap and cinder labor	0.062
All other	Ingot distribution	0.004
	Mould yard labor	0.022
	Scrap and cinder drop labor	0.048
	Inspection and stripping ingots	0.001
	Transportation	0.035
	Other general	0.035
	Total	$0.829

The fixed charges against the open-hearth furnace, costing $275,000 per unit, and figured at 16 per cent for interest, depreciation and taxes, becomes $0.610 per ton of steel produced. The cost of an electric-furnace plant of the same daily capacity is approximately $500,-

TABLE III—LABOR IN REPAIRS

Item	Cost per Ton of Steel
Narrow gauge, ladles, etc	$0.007
Charging machines	0.003
All machinery except charging	0.017
Furnaces	0.009
Metal mixers	0.005
Grinders and all drying apparatus	0.002
Ingot stripper	0.002
Scrap drop	0.001
Buildings	0.002
Yards, sewers, etc	0.006
Bins, tracks, trestles, etc	0.006
Total	$0.060

000 per unit, and including a 4500-kw. electrical equipment per unit, which, assuming the same rate of depreciation as the open-hearth plant, carries a burden of $1.110 per ton of steel produced, using 16 per cent as per above.

The electric furnace consumes electrodes, and a figure of $0.340 per ton of steel is given as a fair average. In the induction type of furnace this would be eliminated, but with an increase in power consumption.

The summary of the situation is given in Table IV.

There are some electric furnaces operating in this country of sufficient capacity to produce facts as to costs for the above comparison, but when an electric furnace operating on castings or special steels produces steel at a cost of approximately $20 per ton of steel, it is not logical to suppose that the same equipment can produce steel at a sufficiently low cost to compete with the open-hearth furnaces in the manufacture of commercial steels. All steel works produce scrap, which must be remelted and made of value, and the amount of

TABLE IV—SUMMARY

Item	Open Hearth	Electric Furnace
Investment, per unit, 200 tons daily capacity	$275,000.0000	$500,000.0000
Interest, depreciation, etc., 16 per cent	0.6100	1.1100
Raw materials (Table I)	14.1034	17.6924
Plant overhead cost and producing labor (Table II)	0.8290	0.8290
Labor in repairs (Table III)	0.0600	0.0600
Electrodes		0.3400
Other overhead	0.0100	0.0100
Total cost per ton of steel	$15.6124	$20.0414

raw materials consumed in the manufacture of steel must remain approximately the same, so that other figures enter into the calculation such as have been tabulated. Accordingly, until the large factor in the cost of making electric furnace steel—the cost of power—is reduced, the electric furnace cannot compete with the open-hearth in the manufacture of steels for rails, structural shapes, merchant bars, etc. In order to do so electrical energy must be produced at a cost lower than $0.001 per kilowatt hour and the present electrical equipment using blast furnace gas cannot do better than $0.007 per kilowatt hour.

Analytical and Laboratory Balances.—CHRISTIAN BECKER, INC., in its recent catalog for balances for chemists and assayers announces the removal of its factory from New Rochelle, N. Y., to Jersey City, N. J., with an office at 92 Reade Street, New York. The catalog contains illustrated descriptions of its principal types of balances with data on capacity, sensitiveness and dimension.

Mercury production in Austria in 1913, according to the report of the Minister of Public Works, amounted to 820 metric tons, valued at $89,208, being an increase of 57.4 tons, but a decrease of $19,145 in value, as compared with the previous year. The entire production came from the Idria mine. Six other mines were then idle.

Production of Zinc Oxide from Low-Grade Carbonate Ore at Leadville

(Editorial Correspondence)

The year 1910 marked for Leadville the beginning of one of those eras of prosperity that make up the varied and interesting history of that remarkable mining district, for in that year the deposits of zinc carbonate were discovered and became the basis of a profitable industry.[1] Ore of shipping grade, say 30 per cent to 35 per cent zinc, was found in large quantities, and thousands of tons were shipped to smelters. It is estimated that during the year 1911 over $3,000,000 worth of zinc in the form of carbonate and silicate was mined and shipped. During the past five years production has continued, and from time to time the smelters have modified their requirements as to grade until at times carbonate ore containing as little as 20 per cent zinc has been marketed.

The limitations of the smelting process, however, prevented the economic treatment of lower grades of carbonate ore which existed in abundance. In Butler's study of the ores[2] he encountered all grades, ranging from practically pure smithsonite (carbonate of zinc) containing about 50 per cent zinc, down to limestone impregnated with zinc, iron and manganese, assaying 15 per cent zinc or less. Smithsonite predominates, and is usually dark reddish or yellowish brown in appearance, soft, porous and earthy. In some compact varieties the mineral is more granular, but without apparent crystalline structure.

Early Proposal of Igneous Concentration

Owing to the physical condition of the zinc carbonate and its intimate association with silica and oxidized forms of iron, the ore is not amenable to ordinary methods of gravity concentration; nor has success been met in recent efforts to adapt some form of flotation to the concentration of these ores. As a consequence, from the time of their discovery until recently, the economic treatment of the low-grade carbonates had not been accomplished. The situation early attracted the attention of metallurgists who realized that the eternal low-grade ore problem would have to be confronted here as elsewhere. Clerc[3] made numerous suggestions for the fire concentration of the ores, with the object of producing a high-grade zinc oxide for subsequent reduction to spelter. In general he voiced the sentiment of other metallurgists who regarded igneous concentration as a logical and feasible process.

In 1914 the Western Zinc Mining & Reducing Co. was organized among Oklahoma oil producers, and a mill was erected at Leadville for the production of zinc oxide from low-grade carbonate ore. The plant was

[1] "From 1860 to 1876 Leadville was a placer gold camp, and little actual mining was attempted, but the discovery of carbonate lead ore in 1874 directed the attention of miners underground. At first only lead and silver (in the form of cerussite and of cerargyrite) were mined, but later extensive deposits of oxidized manganese-iron ores were found; and deeper exploration revealed large bodies of sulphides—mainly galena, sphalerite and pyrite. In 1891 ore chiefly valuable for its gold content was first encountered, and, following the depreciation in the value of silver in 1893, Leadville attracted wide attention as a gold district, although the other metals named were still mined in large quantities. Early in 1910 most of the larger known deposits had been worked out, many of the mines had been abandoned, and it was believed that the great camp with its production of over $380,000,000 was practically exhausted. Then suddenly the mining world was electrified by the announcement that enormous quantities of oxidized zinc minerals had been discovered." Some Recent Developments at Leadville. By G. Montague Butler. *Economic Geology*, Vol. VIII, No. 1, January, 1913. Also *Quarterly*, Colorado School of Mines, April, 1913.

[2] *Ibid.*

[3] F. L. Clerc. The Utilization of the Zinc Carbonates and Silicates of Leadville, Col. *Proceedings* Col. Sci. Soc., Vol. X, pp. 85-98. Also in this journal, A Zinc Retort with a Copper Bottom, August, 1912, p. 463; and The Igneous Concentration of Metallic Values from Mixed Sulphides, April and May, 1914, pp. 250 and 307.

ready for operation in July, 1914, and a short trial run was made just prior to the outbreak of the European war, when the ensuing industrial disturbance in this country caused the company to cease operations. The plant was closed and remained idle until a few months ago, when it was taken over by the Western Zinc Oxide Co., a local organization, under the technical direction of Mr. A. B. Augustine, who originally designed the mill. Operation has now been continuous since.

The Leadville Works

The zinc oxide works at Leadville consists essentially of a furnace, cooling flue and bag house, with the necessary fans for furnace blast and bag house pressure.

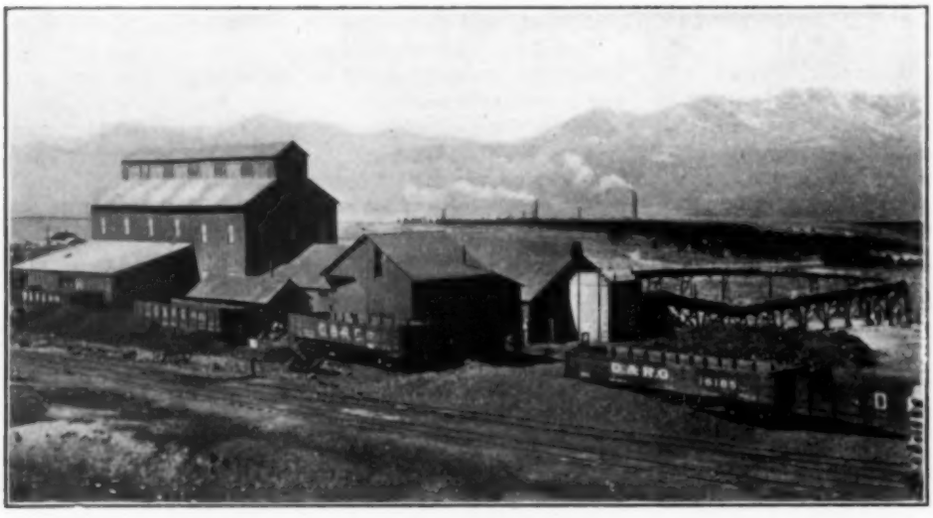

FIG. 1—ZINC OXIDE WORKS, LEADVILLE, COLO.

The plant is simple in design and construction, and the process also is simple in principle and theory. Success in practice lies in intelligent supervision, the proper proportioning of furnace charge, blast pressure and air volume, and the education of workmen to a point where they have some conception of what the process is designed to accomplish. As the Leadville plant is situated at an altitude of over 10,000 ft., special consideration had to be given to the volume and pressure of air required for an oxidizing process. Fans, flues and bag house have been designed to meet these requirements, but many details incident to successful operation have had to be determined experimentally.

Wetherill Type of Furnace

The furnace is of the Wetherill type, 65 ft. long, 16 ft. 6 in. wide and 11 ft. high, built of brick and divided into eight double-ended arched fire-boxes extending across the furnace and having a fire-door at each end. The grate area of each double fire-box is 13 ft. 6 in. by 6 ft. 9 in.

The foundation is of concrete and forms eight watertight compartments beneath the fire-boxes. These compartments are kept filled with water so that the moisture evaporated below the grates may keep the clinker open and porous and aid in the process of oxidation. According to the original design the water compartments were connected by small openings through the transverse walls; but as these openings have sometimes become clogged with cinder falling through the grates, preventing free circulation of water from one compartment to another, a separate water pipe to each compartment has been provided.

The grates are formed of perforated cast-iron plates 11 in. wide, 6 ft. 9 in. long and 1¼ in. thick. The perforations taper from a diameter of ¾ in. on the underside to ⅛ in. on the upper. The ends of the plates rest in the furnace walls and the centers are supported by rails extending across the furnace. The fire-boxes are arched in semi-circular form from the grate level. Above these arches and at right angles to them is the main central arch extending the full length of the furnace and communicating with the combustion chamber at the end.

Extending along the top of the furnace is a 24-in. air main, from which 8-in. pipes conduct air to the pits under the grate of each compartment. The volume of air delivered is regulated by sliding dampers in the 8-in. pipes. A Sturtevant blower supplies 4-oz. blast to the furnace at the rate of 32,000 cu. ft. per minute.

From the combustion chamber a U-shaped cooling flue 4 ft. in diameter and 600 ft. long extends to the bag house. The flue is supported on wooden trusses every 20 ft. It has expansion joints every 50 ft. and small dust hoppers every 10 ft.

Bag House

The bag house contains 288 cotton bags 24 in. in diameter and 26 ft. long, suspended in the usual manner and connected at the bottom with hoppers. The total filtering area is 47,000 sq. ft. The volume of gas handled is about 40,000 cu. ft. per minute, giving a unit filtering area of approximately 1.2 sq. ft. per cubic foot of gas per minute.[4]

The bags are arranged in lateral groups of twenty-four each, with a hopper for every four bags. Each lateral group has a separate connection with the oxide flue, so that the flow can be cut off periodically to shake the bags and clean the hoppers. A National exhaust fan draws the fume from the cooling flue and forces it into the main bag-house conduit and thence to the laterals and bags. The pressure is just sufficient to keep the gases moving through the cooling flue and to prevent back pressure on the furnace.

FIG. 2—PORTION OF COOLING FLUE

[4] This compares with 3.45 sq. ft. per cubic foot of gas per minute in lead smelting practice at Murray, Utah, the area being reduced to 2.5 sq. ft. when one compartment of the bag house is closed. See Notes on Bag Filtration Plants, by Anton Eilers, original communication to the Eighth International Congress of Applied Chemistry; also this journal, Sept. 12, 1912, p. 588.

Preparation of the Ore

The ore treated contains zinc mainly as carbonate, with but little silicate. The latter would not be suitable for the process as it would not decompose readily at the temperature of operation. The average grade is 18 per cent zinc, with a minimum of 16 per cent. The ore is purchased on analysis of a sample secured by taking every tenth shovelful as the lot is unloaded from the car. Lead is an undesirable element, but does not exist in quantities of more than 0.1 per cent in the ores treated.

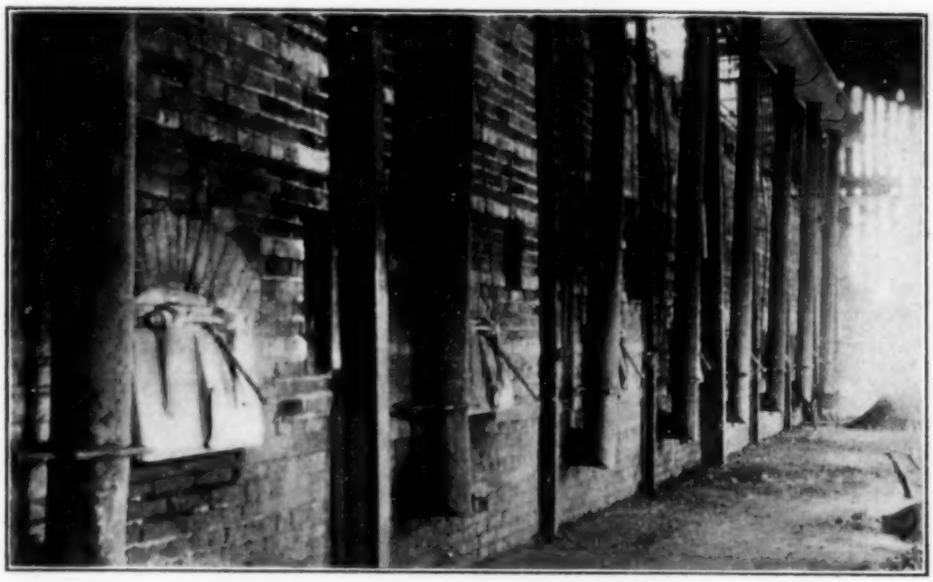

FIG. 3—ONE SIDE OF EIGHT-COMPARTMENT FURNACE

Ores containing more than 2 per cent to 3 per cent lead are not purchased.

A Jeffrey swing-hammer pulverizer is used for crushing, the product being elevated and screened through a 3/16-in. trommel screen and the oversize returned to the pulverizer. This machine has displaced a Blake crusher and a set of rolls and is giving better satisfaction than the former equipment. The ore varies in moisture content, and some of it is so wet as to give trouble in crushing with jaw breakers and rolls. The swing-hammer machine obviates these difficulties and has shown a capacity of 50 tons in 8 hours, which is ample. The same pulverizer serves to prepare the anthracite coal which is used in the smelting mixture after being crushed to abount 5/16-in.

Ore and coal are trammed to the furnace room and dumped on a concrete floor for mixing. A charge for one double-ended furnace compartment consists of 2000 lb. ore and 1100 lb. coal, divided into two equal portions for the fire-boxes on opposite sides of the furnace. Mixing is done by shoveling, the pile being turned over once dry, then wetted to contain about 20 per cent moisture and turned over again. In a larger plant mechanical methods of mixing might be more economical, but at the Leadville works the necessary furnace attendants have ample time to prepare the charge by hand and the method gives satisfaction.

Operation of the Furnace

The eight fire-boxes are charged at both sides simultaneously, and in rotation from No. 1 to No. 8. One hundred pounds of coal is first thrown over the hot grate, 50 lb. from each side, and when ignition has begun the charge of ore and coal is shoveled in and leveled. The blast is reduced in volume at the beginning of the operation and gradually increased as the charge becomes ignited. The furnace foreman regulates the blast and rabbles the charge occasionally to prevent the formation of blow holes and insure a bed of uniform density. In six or seven hours the zinc is driven out of the charge. The sinter is then withdrawn and taken to the dump, and a new charge added. At this rate of operation the furnace has a capacity of 30 tons of ore in 24 hours.

Under the present method of operating the sinter carries from 2 per cent to 4 per cent zinc, which is an improvement over earlier practice, resulting from a better proportioning of the slag-forming elements in the ore. The ores vary in iron and silica content, and are mixed to give a nearly neutral sinter, with iron slightly in excess owing to the greater abundance of that element.

The furnace temperature is about 1000 deg. C., but by the time the gases have passed through the long cooling flue they enter the bag house at a temperature of about 140 deg. C. Cooling by radiation is augmented by the admission of air at a number of the hoppers near the bag-house end of the flue.

The bags are shaken by hand every two hours and the hoppers are emptied once in 24 hours. The product is a high-grade white zinc oxide, containing 76-77 per cent zinc, equivalent to 95-96 per cent zinc oxide. It contains also from 1 to 1½ per cent lead, and is suitable for use as a pigment without reburning. The ratio of concentration is between 4 and 5 to 1, and production amounts to about 6 tons of oxide per day.

As matters now stand the Leadville works should become an economic factor in the mining and treatment of low-grade zinc carbonate ores. Time and experience have served to remove many of the difficulties encountered in the trial run of a year ago. Bag-house capacity is apparently ample, and slag and fume losses have been reduced to a minimum. The labor problem grows less acute as the men become educated in the details of operation, and the process is now working to the satisfaction of its promoters. The plant is favorably located with regard to transportation facilities, ore and fuel supply and power, and apparently no unfavorable conditions now exist to prevent continued success.

Antimony has been found in many places in Mexico, especially in Durango, Sonora and Oaxaca, and relatively small amounts of ore have been shipped to the United States for smelting; however, the Catorce deposits have been the best producers for the last 20 years. The mining ores run from 25 to 70 per cent pure antimony. Antimony appears in many ores treated at the lead smelter in San Luis Potosi, but its presence in these ores is deleterious, and in the bullion it is regarded as an impurity.

The vapor pressure of arsenic trioxide is the subject of Technical Paper No. 81, of the U. S. Bureau of Mines. The authors are H. V. Welch and L. H. Duschak. The paper embodies the results of an investigation undertaken with a view to the proper design and control of equipment for recovering arsenic from smelter gases.

Chemical Principles of the Blast Furnace

BY J. E. JOHNSON, JR.

(*Concluded from page 543*)

The Removal of the Sulphur

Sulphur may be introduced into the furnace by any of the raw materials, the fuel, the ore, or the flux, their responsibility for its introduction being in the order given.

The flux generally contains only traces of sulphur, but one case came under my observation in which the management of a charcoal furnace was greatly disturbed and equally puzzled to find the sulphur in their iron too high with no apparent reason for its being so. Analyses of the ore and then of the charcoal showing nothing out of ordinary, they finally analyzed the limestone and found enough sulphur to account for all the trouble. I think the amount was about 0.3 per cent, which was sufficient to spoil charcoal iron, because the slag on which it was made was so acid as to leave in the iron a considerable proportion of the sulphur in the charge.

Most of the ores of the Lake Superior region are very free from sulphur, although several of these on the Menominee range contain as much as two or three-tenths. The ores of the Virginia and Alabama iron districts contain in general only the faintest traces of sulphur, as do most of those of the East, but some of the magnetites of New Jersey and Eastern Pennsylvania are high in sulphur, in particular, the ore from the Cornwall mine near Lebanon, Pa., the largest and most famous single mine in the East, which has been worked continuously since revolutionary times; it contains on the average about 2 to 3 per cent of sulphur and cannot ordinarily be used in the furnace without giving it a preliminary roast, which reduces the sulphur in unconcentrated ore to between 0.5 and 1 per cent. A large proportion of this ore is now crushed fine and magnetically concentrated, after which the fine concentrates are nodulized in a rotary kiln, and this in good practice reduces the sulphur to 0.05 per cent or under. Some of the magnetites of Canada are also high in sulphur, running 3 to 4 per cent in their native condition, and these are either crushed fine, concentrated and agglomerated, or treated by roasting, which reduces the sulphur to within permissible limits for furnace use. In general if an ore is rich and pure enough in other respects to be worth the treatment it can be so roasted as to lower the sulphur within easily usable limits.

SULPHUR IN FUEL

Charcoal is free of sulphur to a far greater extent than any other furnace fuel, but varies within quite wide limits. Charcoal from hardwood, exclusive of its bark, nearly always contains well under 0.1 per cent and even down to 0.02 or 0.03 per cent, while the bark may simultaneously contain 0.2 or 0.3 per cent or even more sulphur; but the bark is such a small proportion of the whole that good hardwood charcoal probably averages under 0.1 per cent of the whole.

This small amount is largely absorbed even by the most acid slag, and only a small quantity enters the iron, under 0.02 with good raw materials, in ordinary practice.

This absence of sulphur and the consequent absence of need to run the furnace for desulphurization constitute the fundamental difference between charcoal and coke or anthracite practice and the irons resulting from them.

Coke contains all the way from 0.6 per cent to 2 per cent sulphur, which is present in two forms, ferric and ferrous sulphide, FeS_2 and FeS, and vegetable compounds.

The sulphur combined with iron occurs in the form of pyrite FeS_2 in the coal, but the heat of the coking operation drives off one molecule of sulphur from some of the pyrite and leaves it in the form of FeS in the coke, so that coke makers have a rule for general use that the diminution of sulphur is just about the same as the loss of weight in coking, so that the percentage of sulphur in coke is about the same as that of the coal from which it is made. I believe that the classification of coke into good and bad as regards sulphur in the minds of most furnacemen is based on whether it is above or below 1 per cent. The original Connellsville coke had only about this and the New River and Pocohontas considerably less, but the sulphur in some of the Western Pennsylvania fields outside the Connellsville basin are higher and much coke is now used running 1.25 per cent and upward in sulphur.

I have known of a case where a plant ran for a considerable period on coke of nearly 3 per cent sulphur, but as the manager said, "I had to disregard coke consumption in order to make good iron." In another case a plant was run for a term of years on coke of 1.75 per cent sulphur.

As the sulphur specifications for steel mill irons are "under 0.06 per cent," and for all merchant iron "0.05 per cent and under," or in some cases "0.03 per cent and under," it is obvious that nearly all the sulphur brought in by the raw materials must be eliminated.

The method by which this is done consists principally, if not solely, in carrying the sulphur off with the slag as calcium sulphide CaS, there being no considerable portion of the sulphur carried off by the gas. There may be volatilization of sulphur in the hearth, but if so, the vapor formed is caught by the slag as it rises through the bosh and brought back into the hearth, so that the net effect of such an action is nil. The existence of such a condition has never been investigated as far as I know. Sulphur is always thrown off by a hot coke-furnace slag, in many cases in heavy volume, but this may be due to the oxidation of CaS of the slag to CaO and SO_2 with the oxygen of the air, a reaction which could not take place in the reducing atmosphere of the hearth, so that this evolution of sulphur from slag in air is no proof of a similar condition in the furnace.

The reactions by which calcium sulphide is formed are not very definitely known, but involve the reducing action of carbon to assist the reduction of the calcium from the oxide to the sulphide presumably by reactions somewhat as follows:

$$FeS + CaO + C = Fe + CaS + CO$$

This is the reaction given by Prof. H. M. Howe in his "Iron, Steel and Other Alloys," and is probably correct in principle if not exact in detail. The sulphur which is present as an organic compound is presumably carried off in a similar way, but nothing definite is known about the details of the reaction. It seems certain, however, that the sulphur cannot reduce lime to calcium sulphide without the assistance of the reducing action of the carbon. As a matter of fact the reactions are probably not so simple as indicated, since the silica exerts a powerful attraction for the lime and there must be enough of the latter present to satisfy the silica before much sulphur is removed.

We encounter here for the first time the fact which should be impressed upon the mind of every student of this subject and which is too little realized or taught in metallurgy:

The chemistry of the blast furnace is not a chemistry of definite atomic proportions but it is a chemistry of infinitely varying balances among conflicting tendencies.

A homely illustration is that if you place a heavy book upon the seat of a rocking chair the chair will take up a certain position; if you push the book back the chair will tip back and if you pull the book forward the chair will tip forward, its motion being roughly proportional to the movement of the book. If the rule of definite atomic proportions held the rocker of the chair would consist of only two or three straight sections of definite length and making considerable angles with each other, and the book could be removed through considerable distances without affecting the position of the chair, then when it did move it would rock instantly from one straight section to the next and remain at rest in that until the book had been shifted through another considerable range.

Nothing could be further from the facts of furnace operation than the last illustration, nothing be more like than the first. Each change of conditions sufficiently large not to be masked by the continual variations of operation produces its proportional effect, and these effects shade from one to the other by imperceptible gradations. It is, I think, this law which scientists have tried to capture and brand as "The Phase Rule." It is perhaps the misfortune of my generation that we had passed our student days when this rule was enunciated to the public and so did not grasp the new conception which it tries to codify, so that the simple relations which are used to illustrate the workings of the phase rule do not seem to need or receive additional light from it, and the more difficult ones whose explanation is sought by its assistance are made the harder for us to understand by the introduction of its difficult terminology. To another generation trained to think in this terminology from their collegiate years it will, we may hope, prove a benefit, but for the purposes of this work plain statements of fact with such homely illustrations as the above must suffice.

Returning now to the subject of desulphurization, the condition surrounding it and the number of substances involved in the operation is too great to permit its investigation without a vast amount of experimental work and overcoming many difficulties. We know, however, as the result of observations on operation four factors upon which desulphurization depends: First, the relative excess of bases over acids in the slag (positive); second, the temperature of the slag (positive); third, the fluidity of the slag (positive); fourth, the concentration of sulphur in the slag (negative).

The bearing and results of these laws may be more properly discussed under the head of furnace operation and need not be further considered here.

The Reduction of Silicon, Phosphorus, and Manganese

These elements are all more difficult to reduce from their oxides than iron and therefore it should theoretically be possible to run the furnace so that iron would be reduced but none of these impurities. But as a matter of fact it is not possible to do so; if they are present in the charge they will be found in the iron to some extent. We can vary this extent very much in the case of two of them, but even here we cannot exclude them altogether under practical operating conditions, if at all.

This is for the reason that iron exercises a solvent action upon all three elements and forms a definite compound with at least one of them, and probably the others also. The difference between a physical solution like that of caustic soda in water and a chemical combination like that of caustic soda with hydrochloride acid is not so great or at least so readily distinguishable at the high temperatures in the health of the furnace, and I do not feel qualified to distinguish between them in all cases. But it seems likely that manganese forms with iron only a solution or perhaps with the carbon in the iron a double carbide, the silicon acts as if formed silicide and a solution of this silicide in the iron, while phosphorus is known to form two or three definite phosphides, and solutions of some of these in iron.

Without attempting to pass definitely upon the question of whether the iron merely dissolves the silicon and manganese or really combines with them, we know that it has a considerable affinity for all three of these elements, and this fact has a strong influence in their reduction from the oxide to the elemental condition in which they are taken up by the iron. This is important because all of them are more difficult to reduce than iron requiring a higher temperature and a greater quantity of heat per unit of element reduced than does iron, and if the reducing action were not assisted by the affinity of iron for these substances in their elemental condition it is probable that they would not be reduced at all or in much less degree than they are.

The case is analogous to that of copper smelting which utilizes the power of copper as a "catcher" for silver and gold. The ores of these metals are charged into the copper furnace and a very large proportion of their values is caught by the copper matte, from which they are subsequently recovered by electrolytic refining; but if the copper were not there to act as a catcher these values would largely be lost in the slag and the fumes.

It is believed that all three elements under discussion are deduced by solid carbon and not to any extent by CO.

Phosphorus is more completely reduced than either of the other two. This may be because of its stronger affinity for iron rather than to greater inherent reducibility, and practically all of this element present in the charge passes into the iron unless the furnace is working "cold" with a scouring slag, when as much as 10 per cent of it may, according to Sir Lothian Bell, pass into the slag. From my own observation, I should say that even a considerably greater percentage of it could be eliminated in this way, but as this never happens except when the furnace is working very badly it is a matter of no industrial or commercial importance, and I have never investigated it.

It is stated in Sexton and Primrose's "Metallurgy of Iron and Steel," pp. 61 and 62, that phosphorus is not reduced at all by incandescent carbon except in the presence of silicon in excess. The phosphorus is generally present in the ore as tricalcium-phosphate and the reaction is said to take place according to the equation:

$$Ca_3P_2O_8 + 3SiO_2 + 5C + Fe = 3CaOSiO_2 + 5CO + FeP_2$$

Silicon is always present in excess in the charge and so the phosphorus can always be reduced even if this be a necessary condition. In the absence of any experimental data on the reduction of phosphorus in a furnace working without silica in the charge it is really more or less an academic, rather than a practical question whether this is a necessary condition or not. But I incline to the belief that while incandescent carbon alone may be unable to reduce phosphorus from the calcium phosphate, incandescent carbon in the presence of molten iron in excess might be able to cause the reaction to take place even in the absence of the silica; this is, of course, equivalent in a rough way to saying that the affinity of iron for phosphorus is probably as great as that of lime for silica so that the occurrence of the former reaction would compensate for the absence of the latter, but for practical purposes this is merely speculative.

The percentage of the total manganese changed which is forced into the iron depends upon the temperature at which the furnace is worked and the basicisity of the slag, from a half to two-thirds of the whole amount charged will pass into the iron in ordinary coke practice and less than this in good charcoal practice because those furnaces are worked both colder and with a more acid slag, though charcoal furnaces *can* be worked to throw as great a percent into the iron as can be done with coke. A part of the manganese is lost in the slag and a part by vaporization in the hearth, the latter can be plainly seen at furnaces making ferromanganese passing out the stacks of the stoves and boilers as a very heavy yellow fume.

The relative amounts lost in these two ways depend on the hearth temperature and the composition of the slag. Raising the hearth temperature tends to increase the vaporization loss and to diminish the slag loss while acid slag increases the slag loss rapidly without much effect on the vaporization loss. Cases are on record of unsuccessful attempts to make ferromanganese in which nearly all the manganese charged passed out into the slag, only an insignificant amount passing into the metal.

Silicon is generally present in the charge in far greater quantity than is needed to supply the percentage desired in the iron. Generally the composition of the raw materials is such as to produce this condition whether we will or not, and if it is not so the furnaceman usually produces it by adding a silicious ore to the charge as it is easier to get the silicon desired into the iron when a superabundance is present than it is to obtain it by robbing the slag of the silicon it needs. In coke practice the silicon thrown into the iron is commonly less than 20 per cent of the silicon of the total silicon charged. On the other hand, I have run a charcoal furnace on rich low-silica ore and made high silicon iron, about 3 per cent, which required more than half the silica charged for its production, but this is not good practice.

It is stated by Sexton and Primrose (*Op. cit.*) that silicon is not reduced by carbon at temperatures below those of the electric arc which means that the affinity it has for iron is strong enough to make up the deficiency in the reducing power of carbon and so the silicon is reduced not to the elemental state, but the state of silicide of iron. This is borne out by the limitations of the manufacture of ferrosilicon in the blast furnace. This material containing as high as 13 per cent Si ordinarily, and higher occasionally, is regularly produced in blast furnaces using very high blast temperatures and a large quantity of fuel per ton of product, but when material containing more silicon than this is desired it is necessary to go to the electric furnace which is quite without those limitations of temperature under which the blast furnace suffers, and in that apparatus it is perfectly possible to produce a material containing from 50 per cent to 80 per cent Si, or higher for special purposes. This is probably explained by the fact that when the iron reaches say 15 per cent Si it is so nearly saturated for this element that it does not exercise any considerable affinity for any further amount and reduction of silicon accordingly ceases.

Since the above was written I have been informed by Prof. J. W. Richards that silica begins to be reduced by carbon at 2750 deg. Fahr. and is reduced quite freely at 3250 deg. Fahr. Whatever may be the conditions as to silica alone the facts of practice are as above stated.

It seems likely that all these elements are reduced on the surface of the incandescent coke in a way exactly similar to the reduction of litharge to lead on the surface of a piece of chemical by blowing on it with a blow pipe. The conditions in the furnace are exactly the same on a large scale. As these elements are reduced the trickling iron running down over the surface of the coke on which they are produced is immediately at hand to take them up.

It has several times been suggested that the silicon of the iron came from the silica of the coke. This suggestion has much to recommend it and is probably largely correct for ordinary conditions, but in the manufacture of forrosilicon in the blast furnace in which the silicon goes up as high as 13 per cent it is obvious that this cannot all come from the coke since ordinary coke contains less than 7 per cent silica corresponding only to about 3 per cent of silicon. This proves conclusively that the silica of the coke ash is not the only source of silicon and indicates the probability here as in so many other cases that the course followed is a compromise between two possible extremes, a balance between opposing influences. The reaction according to which this reduction takes place is then of the form:

$$yFe + SiO_2 + 2C = Fe_ySi + 2CO.$$

SLAG

The impurities of the fuel and of the ore must be eliminated from the furnace. In the early days this was probably done in the same way as taking the clinker out of a domestic fire by prying the clinker up from the bottom and raking it out, but in a furnace over thirty feet in height, which the early furnaces soon came to be, it obviously could not be taken out the top and an opening was provided in the hearth with a fore hearth in front of it, through which access could be had to the inside of the furnace by removing the heavy lid of the fore hearth. This was only done after cast when the blast was off, as at any other time the gas formed in the hearth would have blown out the opening and made work impossible in the vicinity.

Gradually it came to be realized that the slag could be made fusible by the addition of "flux" and that when this was done it was not so necessary to open up the front and "work her down," so that practice declined and died out, but not so many years ago as might be thought, since I can distinctly remember as a very small boy seeing a jib crane, hung from the stone pier of the front arch of the furnace, to the chain of which the keepers hung in turn a huge poker and a gigantic shovel, as I recollect it about two feet square, and perhaps some other tools which were laboriously operated by two or three men who were not as economical of their strength as is now customary.

This was a charcoal furnace, but I am informed that the same practice was retained at the anthracite furnaces perhaps even to a later date.

The early furnaces always used charcoal fuel in which the percentage of ash is small and that present largely lime and alkali while sulphur is almost absent. For these reasons lime was little needed and its use developed slowly, but when soft coal and anthracite came into use, with a much larger amount of ash and sulphur, the latter requiring a relatively basic slag to keep it out of the iron, the use of flux came into regular use.

The principal impurity in both ore and all mineral fuel is silica. Its importance comes from two sources; first, it is generally present in much larger quantity than any other substance, and second, it is a much more active acid, if not the only acid of importance in common practice.

Next in quantity and importance comes alumina, which is very weak chemically, practically neither acid

nor basic, but has a powerful effect on the physical characteristics of the slag.

These combine with mineral bases and the compounds so formed are far more fusible than any of the components separately. For instance, silica melts about 3180 deg. Fahr. and lime alone is infusible even in the oxyhydrogen blow pipe, but these two form compounds which melt about 2100 deg. Fahr.

Advantage is taken of this fact to convert the impurities of the charge into a fusible slag which runs from the furnace easily by adding mineral bases to the charge, even in charcoal practice where sulphur is almost entirely absent, and in coke practice the addition of lime is carried much further so as to render the slag basic enough to fix the sulphur and carry it out of the furnace.

In practice only two bases are ever used, lime and magnesia. This is for two reasons; first, they occur in the greatest abundance in nature, far exceeding all the other alkalies or alkaline earths put together, and in massive geological formations close to the earth's surfaces so that they can be cheaply obtained by quarrying, and second, because they are among the most powerful of all the bases chemically, particularly lime, which will even replace caustic soda in combining with some acids.

Lime alone is often used as flux, but never magnesia. This for two reasons; first, that lime carbonate, which contains only insignificant quantities of magnesium carbonate, occurs in vast quantities in nature, but the reverse is so seldom true as to make the latter compound many times more expensive than limestone; second, the chemical activity of lime is much greater than that of magnesia. It was claimed by Sir Lothian Bell that magnesia was worthless for purposes of desulphurization; experience has proven this not to be true when both lime and magnesia are used together and whether it would be true if magnesia alone were used for flux is a purely academic question since commercial considerations prevent its use for that purpose.

Much limestone contains magnesium carbonate in quantities varying from a trace up to true dolomite, the double carbonate of lime and magnesia, $CaO,Mgo(CO_2)_2$ in which when decarborated the bases are present in the proportion of 41.7 and 58.3 per cent owing to the difference in the atomic weights of Ca and Mg. Dolomite occurs in nature in great quantities also as does dolomitic limestone and these are used as flue either alone or in conjunction with limestone, according to considerations which may be more appropriately discussed under the head of operation.

The combination of those bases with the silica of the charge forms the silicates of lime and magnesia which constitute in all cases more than half the total slag volume and this acts as a solvent for many other ingredients of which the alumina, in my judgment, is one; the principal one in quantity, next to the basic silicates themselves, varying from 7 to 15 per cent in ordinary coke practice but going as high as 35 per cent in certain special cases. The ingredient next in quantity in coke practice is calcium sulphide CaS, ranging from 2 to 5 per cent, but in normal practice from 3 to 4 per cent.

There is always present a certain amount of iron in the form of FeO. This varies from a mere trace in a white cinder made in a hot-working furnace to several per cent in bad working, but under 1.0 per cent in any normal working furnace. Manganese oxide MnO is present in quantities depending on the amount of manganese in the charge, in ordinary irons running under 1 per cent in manganese, the MnO in the slag should be under 0.5 per cent and from this down to a trace. On the other hand when high-manganese irons, spiegel and ferromanganese are being made there are always several per cent of MnO in the slag, even in best practice.

In general the rule that one-third of the manganese charged will go into the slag even if the furnace be operated to throw as much as possible of it into the iron, will define the minimum amount to be expected in the slag, and this may be increased up to a large proportion of the whole amount charged by different furnace operation.

Titanium

Some ores and fuels contain other elements in small quantities which go into the slag or into the iron in varying proportions. One of the most common of these is titanium, which occurs in some cokes and in many ores in amounts varying from a trace up to 15 or 20 per cent, in the form of titanic acid TiO_2

This is extremely irreducible and infusible and its presence complicates the operation of the furnace materially, and for a very unusual reason; this is its affinity for nitrogen since with this and cyanogen it forms a cyano-nitride of titanium. This is highly infusible and does not dissolve in the slag, so remains in the hearth, and gradually fills it up to such a point that the furnace can no longer function properly. It was long held that the presence of a small quantity of this material rendered ore unfit for use in the blast furnace, but the whole question has recently been attacked anew and methods will probably be found whereby it can be fluxed. There is much reason to believe that the former verdict against it was on insufficient grounds.

In some cases the principal impurity in the ore is lime instead of silica, but there is seldom a sufficient excess to do more than flux the ash of the coke. When there is it is not customary to add silica by itself to the charge, but to use a portion of some other commercially available ore with an excess of silica, thereby avoiding the addition of barren material, either acid or basic, to the charge and so killing two birds with one stone.

The red hematites of Alabama and the Minette ores of Lorain and Luxembourg are the two most notable cases of ores of this kind.

The reaction between silica and lime is an exothermic one so that when they are heated to a temperature high enough to permit reaction between them the reaction goes forward more rapidly on account of the heat evolved. At the same time the quantity of heat evolved in this reaction is not comparable with that in many others, being only about 300 B.t.u. per lb. of compound produced as against several thousand in some other reaction. Perhaps for this reason the resulting product differs less in its properties from those of its component substances and acts more like a solution than a chemical compound as compared with those substances which react more violently together.

It is generally believed that the formation temperature of slags is higher than the temperature of fusion so that if lime and silica be heated together they have to be raised to a higher temperature before combining than the resulting slag would require to remelt it.

This is a more or less obvious corollary to the fact that the melting temperatures of the ingredient are higher than that of the compound. It has been found also that the fineness of grinding and the intimacy of contact of the particles have a powerful effect on the temperature of formation which is likewise to be expected for the same cause.

These are facts which are sometimes of capital importance in understanding the operation of the furnace, and we shall have occasion to return to them in discussing that subject.

THE FORMATION OF CYANIDES

This is a subject concerning which not much is known.

The intimate contact of the nitrogen of the blast with the incandescent coke near the tuyeres in an absolutely reducing atmosphere furnishes the condition of high temperature necessary to carry out the highly endothermic reaction between those two elements while there is always present a certain amount of alkali from the ash of the coke with which the cyanogen can unite to form alkaline cyanides, the presence of which around the hearth and bosh has often been noticed.

Several years ago an attempt was made to draw these cyanides from inside of the bosh and turn them to commercial use and while this attempt met some degree of technical success it was not continued and it is safe to say that commercially it was unsuccessful.

It has been suggested that these cyanides played an important part in the final reduction of the ore and it is entirely possible that this is so since cyanogen is a powerful reducing agent and most of the cyanides formed in the hearth must be volatilized and rise through the charge with the gas column until they are either broken up or condensed and carried back by the charge. But so far as I know no critical investigation of this subject has ever been carried on so that little of value is known about it.

Sir Lothian Bell investigated the subject more thoroughly than any one else of whom I have knowledge; his results were published in his "Chemical Phenomena of Iron Smelting," but did not go further than to establish the fact that cyanide occurred in considerable quantities in the hearth and bosh of the furnace.

CALCIUM CARBIDE

All the literature dealing with calcium carbide states that its temperature of formation is so high that this can only be reached in the electric furnace, but in tearing out the hearths of furnaces blown out for repairs and wetting down the material left in them, I have several times noticed the smell of acetylene so plainly that it was unmistakable, and considering that lumps of lime are often found in the hearth under such conditions, when the furnace has been running on a basic slag and that this lime must have come down in contact with incandescent coke at a very high temperature, it does not seem unlikely that a certain amount of calcium carbide should form. It is impossible to say to what extent this reaction takes place, but it has a certain interest in view of the calcium carbide theory of steel purification in the electric furnace, which is receiving quite general acceptance, and as showing that reactions which are commonly stated to take place only at the temperature of the electric arc, do really occur in a limited way at lower temperatures when the conditions are favorable, furnishing a further illustration of the general law of varying equilibrium between contending forces depending on the conditions of temperature, chemical concentration, etc.

There are probably many, if not many hundreds of other reactions, which go on in the hearth under the condition of extremely high temperatures and intensely reducing atmosphere which prevail there, but the above are the principal ones necessary to an understanding of the action of the blast furnace.

The Hollinger mill, Porcupine, Canada, is now treating Acme ore, twenty stamps being in operation. The other half of the new 40-stamp unit should now be in operation. When the entire capacity is being utilized, about 900 tons of Hollinger ore and 500 tons of Acme ore will be handled daily.

Synopsis of Recent Chemical and Metallurgical Literature

Chemical Engineering

Sulphate of Ammonia Production in 1914.—From a bulletin issued by the American Coal Products Company we learn that European statistics for 1914 are available only to a limited extent. The estimate of the world's output may be hazarded at 1,300,000 to 1,350,000 metric tons, as against 1,409,000 in 1913.

As regards the prospects for 1915 it is quite probable that an increase may result from the demand for explosives. For this benzol, toluol and ammonia are required and by-product recovery has been stimulated.

"The by-product coke oven still continues to be the main source of ammonia recovery, and the one that promises the most extension in the immediate future, coal gas works standing next in total output, though much greater in number and more widely distributed geographically. The by-product recovery gas producer, the shale oil distillation process, and the English blast furnaces using splint coal, are also responsible for a certain amount annually. Some is also obtained from the carbonization of bones, and from peat, there being two Italian plants reported as operating on this material.

"The methods by which atmospheric nitrogen is transformed into ammonia, viz., the synthetic process of Haber and La Rossignol, and the manufacture of calcium cyanamid, afterwards treated to liberate ammonia, appear to have been extensively pursued in Germany, because of the needs of war and agriculture. So far the Haber process has not been introduced elsewhere, but the production of ammonia from cyanamid has been carried on in Germany and Italy and to a limited extent elsewhere.

"It is both interesting and significant to note in this connection that a bill has recently been introduced in the German Federal Council to create a nitrogen monopoly in Germany extending to 1922.

"Commercially the season of 1914-15 was one of hope deferred rather than of fulfillment. The unfavorable prospects at the close of 1913 were adequately realized in a market that sagged continually throughout the first half of 1914. The outbreak of war, coming in the quiet season, did not change matters very much either way. The embargo placed on sulphate of ammonia exports by the German government in September, which might have operated favorably on English prices, was in effect neutralized by the unfavorable cotton situation in the United States and the increased risk and cost of ocean transport. Toward the close of 1914 more favorable conditions began to prevail and prices began to have an upward tendency. The monthly English quotations, however, have averaged from 25 to 50 shillings below those of the previous year, and the average for the year is 40 shillings lower."

The production of England was 426,413 gross tons, about 6200 tons less than 1913. The cause of the reduction is the war, the gas works having lost the most heavily. The consumption was 106,000 tons and exports 313,877 tons or nearly 12,000 tons less than 1913. There are no figures on German production, but so far as can be judged by trade conditions, there was an increase during the first half of the year. The total sales for home use by the Deutsche Ammoniak-Verkaufs-Vereinigung was 321,404 tons. Exports for the year were 75,868 metric tons and imports 34,628 metric tons. In the United States 183,000 net tons of sulphate were produced, being 12,000 tons less than 1913. This reduction came mostly in the last half of the year and was due to the influence of the war on the iron and

steel trade. The consumption was 272,000 tons as against 262,000 tons in 1913, showing an increase even though production decreased. The possible yearly recovery from coal now carbonized is 700,000 tons, showing that there is an enormous production available from coke, provided that it was all made in by-product ovens.

The Coking of Coal at Low Temperatures is the title of Bulletin No. 79 of the University of Illinois Engineering Experiment Station, the authors being S. W. PARR and H. L. OLIN. (Price, twenty-five cents.) This bulletin describes experiments which were a continuation of the work described in Bulletin 60, the later experiments being conducted on a larger scale. The object of the experiments was to test the coking properties of coals from different sections in Illinois, at temperatures between 400 and 500 deg. C., and to test the resulting by-products. The apparatus used in the coking experiments is shown in Fig. 1 in which *A* is a boiler-plate

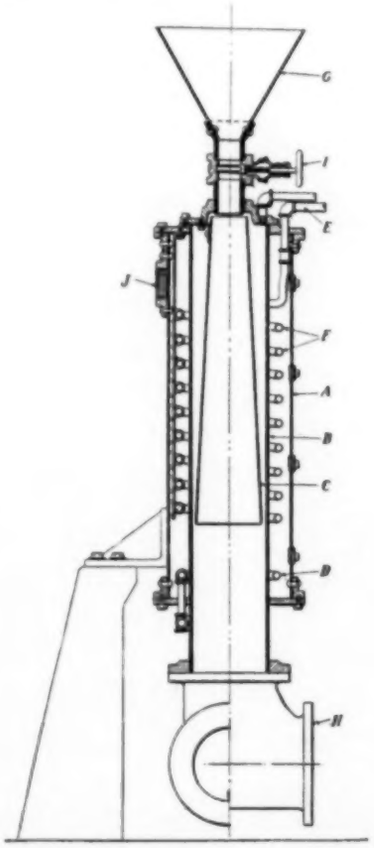

FIG. 1—CROSS-SECTION OF APPARATUS FOR LOW TEMPERATURE COAL DISTILLATION

shell lined with asbestos, *B* is another shell which forms the coking chamber and contains the light sheet iron cone *C* which is perforated. In order to obtain a non-oxidizing atmosphere steam was admitted at *E*. The non-oxidizing atmosphere was found to give better coking results as explained in Bulletin No. 60. The heat was supplied at burner *D* from gas and air mains, and the charge of crushed coal was fed into *G*. The coked residue was removed through *H*, and gases of combustion escaped through *J*. The distillates were conducted to a condenser, and the tars were passed through a water-sealed exit at the bottom.

It was found that better cokes were produced in some cases where fine coke dust was added to the charge, sometimes as much as 100 per cent being required. The coke from one of the experiments was tested in an Otto gas producer and the gas was found to contain negligible quantities of tar and would therefore be useful in internal combustion engines. The efficiencies of the producer compared favorably with those when using anthracite for which the producer was ordinarily used. Heavy hydro-carbons were removed to such an extent that the coke was found to be adapted to household use; being clean in handling and burning. On account of the low temperature the coke had from 18 to 22 per cent of volatile matter remaining, but since it was heated above 400 deg. no tar constituents should remain. This was confirmed by the gas producer tests.

The tar products were next examined and the following results were noted: Average specific gravity 1.069, 18 per cent low-boiling distillate passing over at 210 deg. pitch residue 30 per cent and free from precipitated carbon, high percentage of tar acids making the tar adaptable to wood preservation. Ten per cent of the crude tar was low-boiling distillate free from tar acids and available for use in internal combustion engines. Napthalene was absent and the free carbon in the crude tar was less than 2 per cent.

These experiments were not intended to devise a commercial apparatus but merely to point out in what direction work might be carried on to make a commercial process. The main point brought out in regard to the tar is that low temperatures tend to decrease the amount of comparatively valueless products such as naphthalene and heavy pitch and to increase the production of the lighted and more valuable hydro-carbons.

The Chemical Industries of Austria-Hungary and the War.—In *Chemiker-Zeitung*, July 7, 1915. ED. DONATH and G. ULRICH give an outline of the chemical industries in Austria-Hungary and the war's effect on them. The chief influence hindering normal production has been the inability to carry on commerce, and the lack of raw materials. The labor shortage has also had its effect. The coal industry was severely hampered at the beginning of the war partly from lack of labor and partly from want of means of transportation. It has improved, however, and is now operating at about three-fourths capacity. Inquiries for coal are numerous, but inquiries for coke are very small. There is, however, a big demand for coke by-products and Austria is making big demands on Prussian-Silesian coke production. Germany and Austria are rich in coal lands, Germany in bituminous coal and Austria in lignite, having shipped 7,000,000 tons to Germany in 1913, in which year Austria imported from Germany 12,152,500 tons coal and 1,051,670 tons of coke.

The production of oxygen has decreased since the beginning of the war. In normal times, there are six companies in Austria producing 6 to 7,000,000 cu. meters per year. For sulphuric acid manufacture Austria-Hungary has a plentiful supply of raw material, especially in the rich copper minerals in upper Hungary. Plentiful quantities of salt are available from Galicia and the Austrian Alps. The alkali industries can scarcely fill the needs for alkali salts. In general it can be said that the inorganic chemical industry has improved since its setback at the beginning of the war and new foundations are being established.

In the important fertilizer industry, the suppression of imports of Chile saltpetre must in time exhaust the supply on hand. The production of ammonium sulphate, the most powerful nitrogen fertilizer, is below other years, because the smelting furnaces which use coke are not running to full capacity. The necessity of keeping up a good production of coke for nitrogen by-products has been impressed upon the people by several authors and the Austrian Chemical Society has formed a committee consisting of representatives of different

industries to take up this question. In Norway calcium nitrate, nitric acid, sodium nitrate and ammonium nitrate are made by the Birkeland-Eyde and Schönherr furnaces and ammonia is made in Arendal by the Serpek process.

The great glass and glassware industry has decreased its output through lack of coal and means of transportation. Raw materials for the clay industries are plentiful. The cement industry has been very much affected, there being used in August and September, 1914, only about 40 per cent of the normal demand. The brick industry and steel and rolling mills were also hard hit.

In 1913 the Austro-Hungarian iron and steel industry was producing considerably under normal capacity; this is an international condition, which the Balkan War helped to create. Lately an improvement has taken place in this and the non-ferrous industry, since imports of metals were stopped, and consequently a larger production of copper, lead, zinc, etc., became necessary. There are many mines in Austria which are rich enough to keep up the normal requirements.

Iron and Steel

Electrical Steel by the Acid Process.—In an article on this subject in *Stahl and Eisen*, 1914, No. 3 Albert Müller discusses experiments on the production of acid-electric steel, and shows the advantages and disadvantages of the process as compared with the basic method. A three-ton Girod furnace was used with a hearth made of the following mixture: 80 per cent silica brick, 6 per cent fireproof clay, and 14 per cent tar as a binder. The walls were made of silica brick. The extent to which the lining is attacked in an acid and basic furnace is shown in the analyses given in Table I.

Table I—Composition of Acid and Basic Furnace Materials

	Electric Furnace Hearth			Acid Furnace Walls	
	Before Melting		After 27 Heats,	Before	After 27
Component	Basic, Per Cent	Acid, Per Cent	Acid, Per Cent	Melting, Per Cent	Heats, Per Cent
SiO_2	5,72	80,50	64,60	95,30	83,50
Ca O	46,50	4,30	12,90	1,85	3,55
Mg O	27,60	1,91	2,90	Spur	0,65
Al_2O_3	1,46	3,08	2,65	0,58	0,97
Fe_2O_3	1,85	0,38	0,43	0,57	4,50
Fe O	0,99	1,16	1,93	0,26	3,65
Mn O	0,40	0,27	12,05	0,19	2,36
P_2O_5	0,09	0,02	0,02	0,08	0,08
C	8,60	7,75	1,20	....	....
Ignition loss	14,35	7,80	....	....	....

Table I gives a comparison of the composition of hearth and walls of basic and acid furnaces, before and after melting, and shows clearly the change in silica content due to the charge and also the change in metallic oxides. It will be noticed that the carbon content of the hearth is reduced from 7.75 to 1.20 per cent in the acid furnace. In the basic furnace the carbon does not react with the charge. In the acid furnace, however, it plays an important part in the reduction of silica. In some cases this reduction is too great in the first melt. The reduction of silica by which the silicon content of the metal bath is increased in an acid furnace may be divided into four phases.

1. Reduction from charge, hearth, and walls at normal temperature and conditions. In this case it is mostly reduced from the hearth and walls.

2. Reduction by raising silica content of the slag by introducing sand.

3. Reduction by raising the temperature of the slag. This is accomplished by arcing.

4. Reduction by carbon, according to the formula $2C + SiO_2 = Si + 2CO$.

All of these reactions are more energetic as the temperature of the slag and steel bath is raised. The silica reduction is much stronger in a newly lined furnace. The large amount of silicon withdrawn from the lining and slag makes it unecessary to add ferrosilicon for the deoxidation. This silicon in the metal bath is a better deoxidizer than ferrosilicon which must be mechanically mixed with the metal bath. Manganese silicate in the slag is reduced to a minimum in the acid electric process.

The sulphur content during the process varies considerably but at the end of the charge is as low as the original sulphur content of the charge. In the oxidation period considerable of the sulphur reacts as follows: $FeS + 2FeO = 3Fe + SO_2$, the SO_2 escaping as in the puddling furnace. Some sulphur is added during the introduction of metallic constituents and coke.

In the basic process the iron sulphide is broken up as follows: $3FeS + 2CaO = 3Fe + 3CaS + 2CO$. Phosphorus in the basic furnace is carried into the slag as calcium phosphate, which is not possible in the acid furnace.

Special care is necessary for conducting an acid slagging process, and on account of the difficulty of melting silica a certain basicity of the slag must be maintained. During the early slagging the oxygen in the base to that in the acid should be 1:2. Later in the deoxidizing slag the ratio may be 1:4, but such a highly acid slag is very often undesirable on account of the high temperature required. The basicity may be raised by lime or magnesia. The lime content should be about 15 per cent as a 20 per cent lime slag attacks the lining. Magnesia is usually between 2 and 5 per cent in a good slag. Ferromanganese also raises the basicity of the slag, but if the MnO in the slag is too high (more than 15 per cent) it can be reduced by coke. The MnO content in an acid slag is usually ten times that in a basic. The acidity of an acid slag is 55-60 per cent SiO_2 for good melting and the oxygen in the base to that in the acid should be 1:3.

Good steel can be made in the acid electric furnace without special precautions, but the process is not easy and a good metallurgical knowledge is requisite. The following points are noted in comparing the acid with the basic electric steel process. For the acid process:

1. Less current demanded because of shorter melting period. The desulphurizing and oxydation practically occur together, and no dephosphorizing takes place.

2. Saving in material for deoxidation. All silicon coming from slag and lining.

3. Lower lining, maintenance and repair costs.

4. Lower cost for slag.

The acid electric furnace is applicable, when a material low in S and P is available, and the process produces a good middle quality steel. However, on account of the powerful reaction of the lining it is only available in certain cases.

Buying and Selling of Ores and Metals

The Buying and Selling of Ores and Metallurgical Products is the title of Technical Paper 83, just issued by the Bureau of Mines. Charles H. Fulton, the author, says: The buying and selling of ores and metallurgical products is a great and highly important business in the United States, and one that concerns not only the miner and the metallurgist but the industrial world in general. In this paper the attempt is made to outline clearly its underlying principles, the subject matter being based on personal experience and investigation. The author has endeavored to present the material impartially, and for that

reason many of the statements and figures regarding metallurgical practice should be taken as illustrative rather than as applying exactly to average operating conditions.

In estimating the value of an ore or an intermediate metallurgical product (other than a refined metal) the basis used is the price of the refined metal at some principal market center, such as New York, at the time the valuation is made. The average price of all copper for 1913 was 15.5 per pound, and for electrolytic copper 15.269 cents per pound. The prices for other metals for the year 1914 were as follows:

Lead, 3.862 cents per pound; spelter, 5.213 cents per pound; silver, 54.811 cents per troy ounce. Gold has the standard value, established by law, of $20.67 per troy ounce.

If the metal contents, in pounds for the base metals and in troy ounces for the precious metals, per avoirdupois ton be multiplied by the prevailing price of the refined metals, the sum of the products will be the gross value of the ore.

There is, however, a wide difference between the gross and the net value of a ton of ore. From the gross value must be deducted, first, the total cost of mining the ore, and then the total cost or charge for treatment, which includes some or all of the following items: Freight to treatment plant, milling or smelting charge, charge to compensate for losses of metal in treatment, charge for penalties imposed on undesirable constituents in the ore, charge for freight to refining center, charge for refining the metal, charge to cover the selling costs of the refined metal. Which of these charges are imposed and what the amount of each charge depends on the ore, the method of treatment, and the number of firms that handle the ore and metals in the process from ore to refined metal.

The types of companies that handle ores and metallurgical products may be classified as follows:

1. Mining and smelting companies or mining and milling companies, which control all the operations from the mining of the ore to the production and selling of the finished metal.

2. Mining companies, which mine and sell ore on certain schedules to smelting or milling companies.

3. Custom smelters or mills which purchase ores and also operate refineries and produce refined metals or sell intermediate metallurgical products to refineries. Concerns of type 3 may control mines that furnish a part of their ore supply.

4. Refining companies, which purchase metallurgical products, such as matte, and crude metals, and some ores, and produce refined metals.

5. Selling agencies, which place the refined metals on the market.

It is apparent that an ore or the products derived from it may go through many hands before the finished metal reaches the market, and that metallurgical business may be complex. In this report the essentials of the commercial side of metallurgical work are discussed in some detail.

Morgan Producer Gas Machine and Dyblie Reversing Valves is the title of a catalog recently issued by the Morgan Construction Company of Worcester, Mass. This producer was described in this journal, June, 1915. The Dyblie reversing valves are described and numerous illustrations given of their operation in the catalog. A table is given showing the sizes of reversing valves for open-hearth furnaces. The frontispiece of the catalog is a striking etching of The Edgar Thomson Steel Works by the well-known artist, Mr. Joseph Pennell.

Recent Chemical and Metallurgical Patents

Iron and Steel

Titanium Alloys.—Alloys higher in titanium content than usual are patented by Dr. HANS GOLDSCHMIDT and Dr. OTTO WEIL of Germany and assigned to the Goldschmidt Thermit Co. The purpose of these alloys is to provide a means of adding a higher percentage of titanium to iron and steel baths, overcoming the objections previously maintained. The alloys consist of 15-35 per cent titanium, 1.5-3.5 per cent aluminium, and the balance iron. The aluminium lowers the melting point of the titanium and the alloying qualification is increased and the alloys are free from carbon. The alloy containing 24 per cent titanium and 3 per cent aluminium has been found very useful. (1,136,670, Apr. 20, 1915.)

Electrolytic Processes

Hydrogen Peroxides.—Apparatus for producing hydrogen peroxide is patented by Dr. WALTER WEBER and assigned to Henkel & Co., of Düsseldorf, Germany. It is an improvement over previous apparatus patented Sept. 30, 1913 (1,074,549). The previous apparatus did not permit of a higher concentration than 3 per cent and it was impossible to cool the anodes. The improved apparatus overcomes these disadvantages. Fig. 1 shows the essential features. A is a tube of suitable metal coated on the inside with a thin layer of copper amalgam or silver amalgam cathode. It is closed at both ends by screw caps B-B′, a rod shaped anode C is covered by a tubular diaphragm K. The electrolyte, sulphuric acid, is introduced through D into the tube A, and leaves through outlet E. Oxygen under 100 atmospheres pressure is passed in through F, and rises in the liquid. After electrolyzing with a current density of 5 amperes per sq. cm. at 2 volts, the peroxide solution and oxygen passes through G to another cell of the same type, and so on until the desired concentration is reached. (1,144,271, June 22, 1915,and 1,138,519, and 1,138,520, May 4, 1915.)

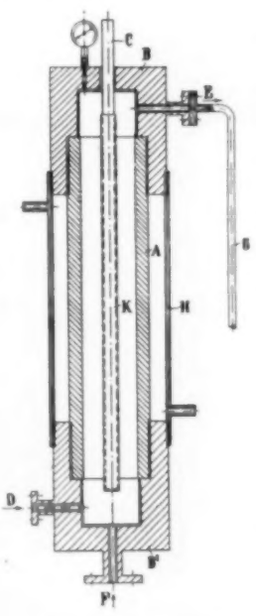

FIG. 1—HYDROGEN PEROXIDE CELL

Potassium Chlorate.—A process of making potassium chlorate by electrolysis is patented by WALTER LAIB of Rittman, Ohio, and assigned to The Ohio Salt Co. In this process a nearly saturated solution of potassium chloride (with a small quantity of chromate) is electrolyzed at a temperature of 35 deg. C. in a cell with carbon or graphite anodes and iron cathodes. This solution is then conducted to a second cell where it is heated by the current up to 70 deg. C. using a platinum anode and iron cathode. In this cell the concentration of chlorate is materially increased and any hypochlorite is converted into chlorate. The solution is then led to a crystallizing vat. The advantages claimed for the process are a saving in cost of anodes over the use of platinum anodes alone and the elimination of hypochlorites. (1,143,586, June 15, 1915.)

Manganese Peroxide Anodes.—A patent issued to Mr. PERCY C. C. ISHERWOOD of England, discloses a process for manufacturing anodes from manganese dioxide ore after treatment for the removal of such

impurities as iron, nickel, or cobalt. The ore is first ground into a finely divided condition, leached with sulphuric or nitric acid, then mixed to a paste with a quantity of manganese nitrate solution and heated. This drives off the oxides of nitrogen and the mass becomes agglomerated. Repeated treatment reduces the porosity of the product. These manganese peroxide anodes are used in copper, zinc or nickel salt solutions as insoluble anodes, and it is claimed that no impurities pass into the electrolyte. (1,143,828, June 22, 1915.)

Fixation of Atmospheric Nitrogen

Oxides of Nitrogen from Air.—A novel apparatus for utilizing the heat of the arc in making oxides of nitrogen from air is disclosed in a patent of Mr. FRANCIS I. DU PONT of Wilmington, Del. In the latest form, the apparatus consists of what might be termed a six-cylinder engine, in which air is drawn in through a valve, compressed and then heated by an arc. This causes the air to expand and forces the piston down or up as it may be; at the same time oxides of nitrogen are formed which are discharged together with the expanded air through a discharge valve. Several automatic adjustments are necessary, viz.: valve action, and the top electrode in the cylinder must be made to move down and touch the bottom electrode just at the beginning of expansion. As the top electrode is moved up, an arc is formed and this arc continues for two-thirds of the stroke of the moving electrode or one-third of a revolution of the crank shaft. The six-cylinder arrangement thus permits of a continuous consumption of current in that each cylinder uses the current for one-third of every other revolution. The cylinder is made in the form of a tube of insulating material; glass or silica, to prevent arcing on the sides of same, thus insuring that the air will be heated to the desired temperature. At the temperature of the arc the nitrogen oxide is formed and the cooling of the air due to expansion prevents to a large extent the redecomposition of the oxides of nitrogen formed. A good working current is given as 2 to 10 amperes at 3500 to 5000 volts. The oxides with the air are discharged into a conduit which leads to the apparatus in which they are to be used. The novel characteristic features of the invention are summed up as follows: "In the first place the electric arc is maintained during expansions, whereby heating, expansion and conversion of the heat into mechanical energy proceed simultaneously, whereby all the heat (except that which is carried off by the gases when expanded to atmospheric pressure and that which, due to the imperfection of mechanical devices, is unavoidably lost) is converted into mechanical energy. In other words, drawing out the arc during expansion, continually generates new heat, which is simultaneously converted into mechanical energy, and after the arc breaks and the generation of heat ceases, the gases continue to expand and convert heat into mechanical energy." (1,147,150, July 20, 1915.)

Carbonitrides.—A process for manufacturing carbonitrides is patented by Mr. SAMUEL PEACOCK of Chicago and assigned to the du Pont de Nemours Powder Co. The essential feature of this patent is the fixation of nitrogen by a metallic oxide and carbon, forming a compound which approximates the formula $Ca_3N_2C_2N_4$ in the case of calcium, and similar formulas in the case of other oxides such as silicon or aluminium. The manner of carrying out this operation is shown in Fig. 2 in which 1 represents a feeder for the charge which goes into the conically shaped revolving furnace. It consists of finely divided dry calcium oxide and finely divided dry coke or charcoal, in the ratio of 56 parts by weight of the former to 24 parts of the latter. An excess of carbon sometimes as high as 25 or 30 per cent is used, since it prevents the formation of calcium nitrides. Five and 6 are resistors for heating to 1500 deg. C. the charge which is gradually worked toward the discharge end by the revolving of the furnace. Twenty-four is a suction pump to withdraw air and gases formed in the reaction. The air is removed from the furnace before starting the operations and nitrogen is introduced in sufficient quantity. The resulting product is calcium carbonitride $Ca_3C_2N_6$. In boiling water or acids it is decomposed into ammonia and carbonates or into ammonium and metal salts of the acid used. (1,137,524, Apr. 27, 1915.)

Electric Furnaces

Calcium Carbide.—Improvements in the manufacture of calcium carbide are described in a patent of Mr. FREDERICK M. BECKET of Niagara Falls, assigned

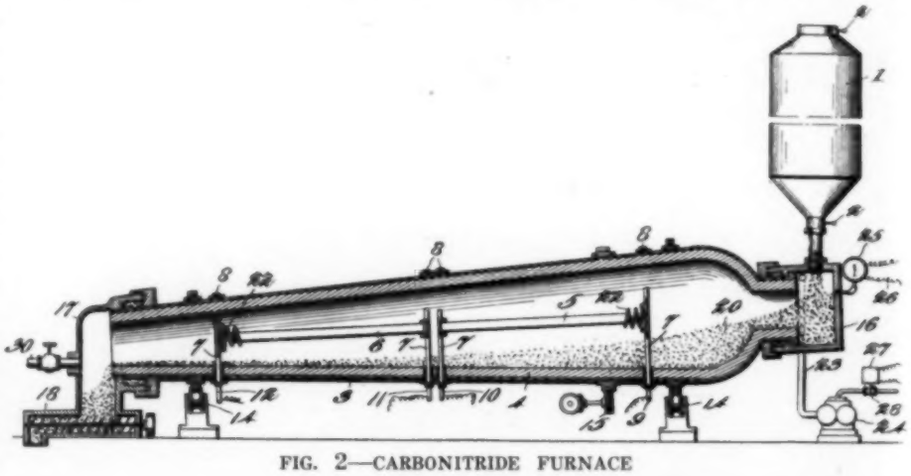

FIG. 2—CARBONITRIDE FURNACE

to the Union Carbide Co. In this process the lime and coal are agglomerated in a by-product coke oven by a coking operation. This is to take the place of briquetting or molding operations and is claimed to be much more economical. In briquetting processes the lime is usually mixed with coke, charcoal or anthracite together with a suitable binder usually a hydrocarbon or carbohydrate. The briquets are formed under high pressure, and baked, if necessary, previous to smelting in the electric furnace.

In the present process calcined limestone is mixed directly with a definite amount of bituminous coal rich in volatile matter. This mixture is then subjected to a coking operation in a by-product coke oven. Grades of coal containing 30 to 36 per cent of volatile hydrocarbons have been used successfully. A coal from the Youghiogheny district in Pennsylvania having the following analysis:

Volatile matter	35.84 per cent
Fixed carbon	53.77 per cent
Ash	10.39 per cent
Total	100.00 per cent
Moisture as received	1.60 per cent

was mixed with freshly burned lime in the propor-

tion of 110 parts of coal to 100 parts of lime, and the mixture was coked in by-product coke ovens of the regular type, the gas, tar, and ammonia being collected as in the usual coking process. The evolved gas was burned for the coking and proved to be sufficient for this purpose. After coking, the resulting mass is crushed to lumps, which may be about the size of the fist, and these lumps then conveyed hot, to the electric furnace. These aggregates are mechanically strong and will endure considerable weathering.

It is necessary to adjust the proportions of lime and coal so that the carbon remaining after the coking operation is practically that required for the reaction.

$$CaO + 3C = CaC_2 + CO,$$

which requires a proportion of fixed carbon equal to about 64 per cent of the lime used. It is this high proportion of fixed carbon required which renders it practicable to supply with the fixed carbon in the coal, a sufficient quantity of bituminous matter to form the strong aggregates. The resulting mixture has been found to have a higher resistance than the ordinary mixtures of lump lime and lump coke, and gives higher yields with less wear on the electrodes. (1,137,567, April 27, 1915.)

A New Multiple-Type Recording Instrument for Pyrometers

The instrument shown in the adjoining illustration has been put upon the American market by Mr. Charles Engelhard, 30 Church Street, New York, in connection with his Heraeus Le Chatelier pyrometer. It is manufactured by Messrs. Siemens & Halske, A. G., Berlin, and conforms in every respect to the high grade instruments for which they are recognized.

The moving system is similar to other types of their instruments, having a double pivoted movement of the D'Arsonval type. The weight of the moving system is extremely small, making it absolutely dead-beat. The ratio between the resistance of the moving coil and the series resistance is so very small that the temperature coefficient is far below that of even a low-resistance instrument. The total resistance of the instrument ranges between 300 and 400 ohms.

Besides being provided with a recording movement, it has also a direct indicating scale, and annunciator, showing the thermo-couple connected at any particular time so that observations may be taken from the instrument as readily as from a direct indicator. The record is formed on a maximum of six thermo-couples, all upon the same chart which is of the continuous roll type, and each record distinguished from every other by being printed in a different symbol. This makes it impossible to confuse the individual records, even though they intermingle or cross at very small angles, and makes it possible to allow the full width of the chart for each record.

But a single galvanometer is employed, the six records being made possible by inserting in the circuit an automatic, mercury contact, switch. This switch is enclosed in the case of the instrument, and forms a part thereof.

The change from one symbol to the next, in accordance with the rotation of the switch, is accomplished by using a roller, situated beneath the chart with six edges, each edge engraved with a different symbol. Over this roller and beneath the chart, slowly moves an inked ribbon. The galvanometer needle, which has a flat surface on its underside, is intermittently depressed every twenty seconds, pressing against the chart, which in turn is pressed against the inked ribbon and engraved edge beneath, so that the symbol on the edge of the roller is printed on the reverse side of the semitransparent chart.

Besides accomplishing absolute distinction between individual records, this method allows the galvanometer needle to swing entirely free between each depression, eliminating all error due to friction. The method further eliminates the necessity of renewing inks or other recording medium.

MULTIPLE RECORDER FOR PYROMETERS

Five hours of record can be observed at all times, as the chart passes down over the face of the instrument. It is then automatically rewound upon a spool in its original form.

The endeavor has been to make this instrument foolproof and thoroughly automatic in every sense. It takes the place of six individual recorders, is compact, extremely accurate, has the advantage of high resistance, and is not affected by vibrations.

Determination of Critical Points in Iron, Steel and Alloys

The Scientific Materials Co. of Pittsburgh, has developed and placed on the market a complete apparatus for the accurate determination of critical points in iron, steel and non-ferrous alloys. A view of the complete outfit is shown in Fig. 1 (p. 644).

The importance to the industries of accurate data on transformation points cannot be underestimated, as the whole field of heat treatment depends upon these phenomena. The Scimatco method is an adaptation of the most sensitive and accurate method which has been devised for detecting and measuring small thermal changes in solid bodies. It is based upon automatic comparison of the temperature, during heating and cooling, of the metal test specimen with that of another "neutral" body, which has no transformation points of its own (at least not within the temperature ranges studied). Both are heated and cooled together in one vertical heating chamber under absolutely uniform conditions.

A convenient manner of introducing the thermocouples into the test piece and neutral body which insures the rapid action of the heat and eliminates scale formation (oxidation) is provided. The critical points are read directly on a specially designed duplex instrument and a special chronograph is provided from the records of which all kinds of curves may be plotted.

In Fig. 2 the general arrangement of heating chamber and bodies is shown, *W* is a coil of resistance wire underneath a metallic plate *T*, which serves as a tem-

perature equalizer. The test specimen with holes drilled for thermo-elements is shown at *S* and the neutral body at *N*. The holes T_1 and T_2 should be at the same distance from the furnace walls.

Two platinum, platinum-rhodium thermo-couples are used, one to indicate the actual temperature of *S* and the other to indicate any difference in temperature between *S* and *M*. These thermo-elements are mounted in special insulating tubes and placed in the drilled holes, as shown in Fig. 3. Scale formation is prevented in this manner.

The duplex galvanometer has one scale for indicating the temperature of the test piece and another scale for indicating differences in temperature of the neutral and test pieces. In case it is desired to take the factor of time into account the special three-pen chronograph and automatic contact clock are provided. These record at regular intervals the actual temperature of test specimen, the difference between test and neutral specimens and speed of heating and cooling and duration of critical ranges. From these records any kind of curve may be plotted.

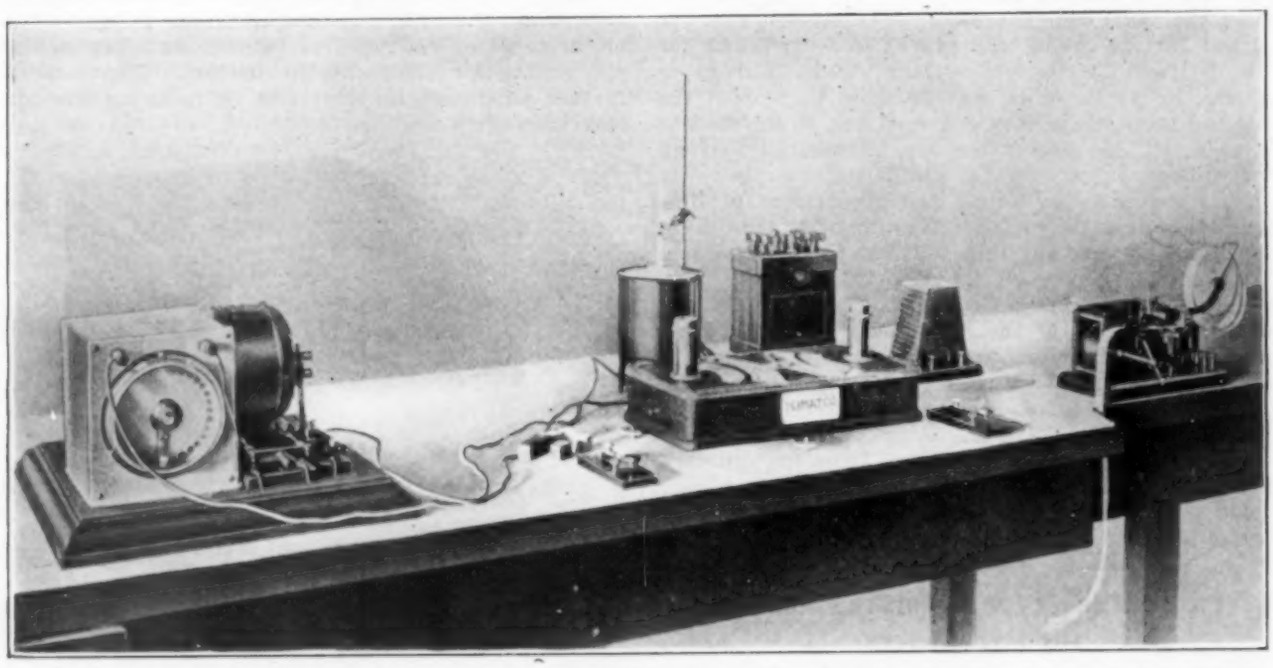

FIG. 1—COMPLETE SCIMATCO OUTFIT FOR THE ACCURATE AND CONVENIENT DETERMINATION OF TRANSFORMATION POINTS

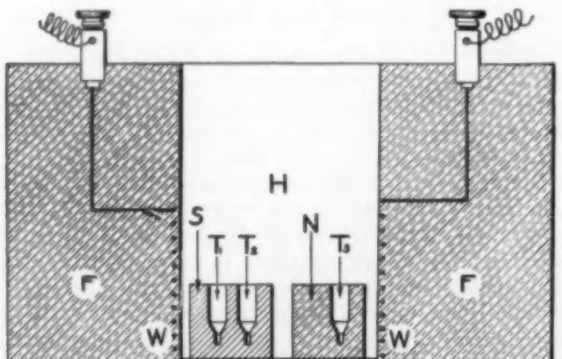

FIG. 2—VIEW OF VERTICAL HEATING CHAMBER WITH TEMPERATURE EQUALIZER AND BODIES

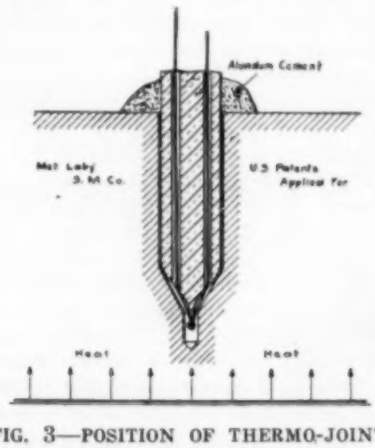

FIG. 3—POSITION OF THERMO-JOINT AND MOUNTING IN THE STEEL BODY

An automatic rheostat for even heating and cooling completes the apparatus, all of which may be seen in Fig. 1.

A metallic alloy suitable for use as packing rings on locomotives using superheated steam is the subject of a patent by G. C. Holder, of Altoona, Pa. The alloy consists of nickel, 3 to 9 per cent; copper, 20 to 30 per cent and lead, 61 to 77 per cent. The hardness of the alloy can be changed by varying the copper content. The composition is comparatively strong and elastic.

The Bausch and Lomb Optical Co. of Rochester, N. Y., has issued a catalog of Optical Instruments for Inspection and Testing of Materials. This catalog describes microscopes for the examination of ores, metals, rocks, concrete, wood, leather, fabrics, paints, varnishes, oils, dyes, inks, drugs, chemicals and foodstuffs. Metallographical apparatus is also included.

Titan Bronze

Through the picturesque Bald Eagle Valley, in Centre County, Pa., runs the Spring Creek. On its banks, in a spot perhaps two miles from the county seat, Bellefonte, there was established, in 1797, the Milesburg Iron Works. Hard by lies the little village of Milesburg, laid out and developed simultaneously with the iron works.

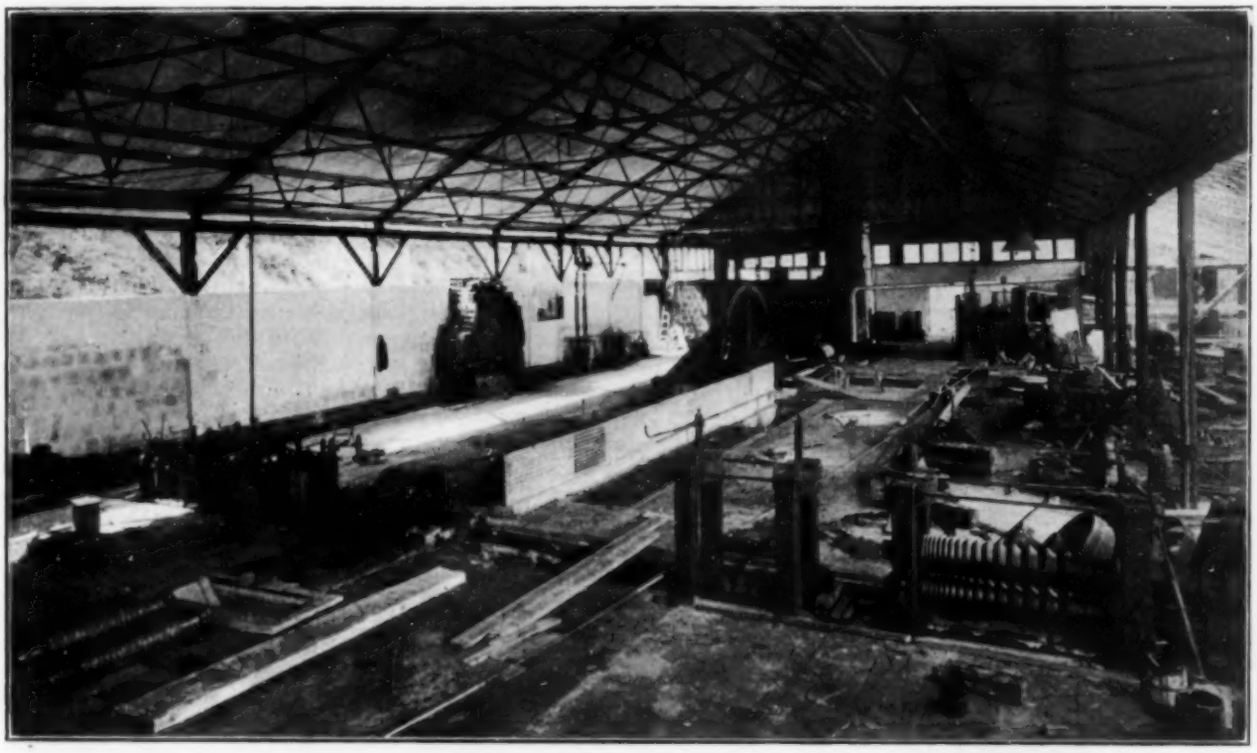

FIG. 1—ROLLING MILL DEPARTMENT OF TITAN METAL CO., BELLEFONTE, PA.

In common they derived their name from their founder, Col. Samuel Miles. During the half century following, the business changed hands six times until in 1849 J. M. McCoy, J. H. Linn and Moses Thompson joined a former part owner, James Irving, in forming the firm of Irving, McCoy & Co. In 1860 Irving withdrew and from that day to this the business has been operated under the name of McCoy, Linn & Co. It is now part of the McCoy estates and is actively managed by Mr. John McCoy.

When the charcoal iron industry was at its height there were operated at Milesburg a blast furnace, charcoal forge, puddling mill, rolling mill and wire mill. Except for the blast furnace the plant lay idle for considerably over a decade until April, 1915. But despite reports to the effect that no iron is now produced in Centre County, McCoy, Linn & Co. have never ceased to operate what is now one of the very few remaining cold-blast, charcoal iron furnaces now active in this section of the State.

After lying thus idle during these many years, title to part of the McCoy property was taken over by the Titan Metal Co. of Bellefonte, Pa., in April of this year. This company is incorporated under the laws of the State of Pennsylvania and is being financed by the business men of Bellefonte. Its officers are C. E. Wagner, president; John Walker, vice-president; W. P. Sieg, secretary and general manager, and F. E. Naginey, treasurer.

The chief product of this company—titan bronze—bids fair to revolutionize certain lines of industry lying within its field.

Titan bronze has been perfected after a number of years of research and experimental work on an elaborate scale. It has high tensile strength and is forgeable. For drop forging it is superior to any similar metal on the market. One of its peculiarly valuable properties is that it can easily be worked hot to a finished form with high tensile strength, and in press work without injuring the dies.

It is supplied in bars, cold rolled and cold drawn, having a tensile strength of 110,000 lb.; in hot-rolled bars and in hot or cold-rolled sheets for hot or cold forming; in castings and recasting ingots. In the very near future the metal world is promised further valuable developments in the form of bronze-covered sheets and bronze wire.

Titan bronze, because of its extremely plastic nature at working temperature, is especially well adapted for drop forgings, gears and pinions, hot press work, roller bearings, balls, valve seats, pump rods, etc.

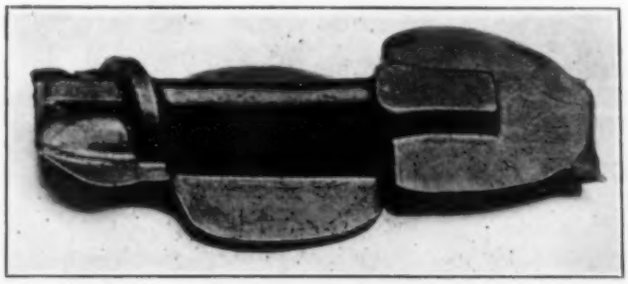

FIG. 2—DROP FORGING OF TITAN BRONZE. LARGE DIAMETER ROD USED TO SHOW SPREAD OF METAL IN FLASH

An ordinary hot-rolled bar of titan bronze will show the following properties: tensile strength, 80,000 lb.; elastic limit, 45,000 lb.; elongation, 25 per cent; reduction of area, 45 per cent.

A tremendous amount of work has been done since the new company took title to the old plant. The substance of a modern fire-proof structure, unsurpassed by

any works of the size in the country, has risen from the skeleton of the old plant. The rolling mill is equipped to handle non-ferrous metals of every description and an inspection of the foundry, stamping mill, casting, drop forge and machine shops affords conclusive evidence that the new concern is well equipped to handle its product in every conceivable form.

Hydraulic Hardness Testing Machine

A new hardness testing machine has been developed and placed on the market by Messrs. Eimer and Amend of New York. This machine works on the well-known Brinell principle of making indentations in the metal and measuring the width of same. It is represented in Fig. 1.

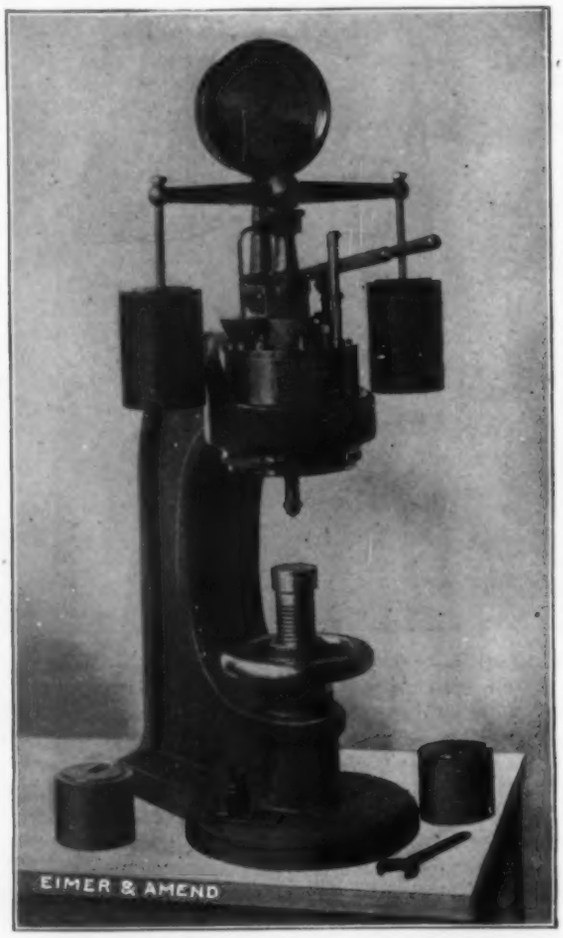

FIG. 1—HYDRAULIC TESTING MACHINE

In order to conform to the demands of most testing laboratories the heavy goose-neck style has been adopted. Controlling weights are provided if desired. By their use wrong readings are entirely excluded; if the manometer should get out of order this device will show the error.

The main parts of the machine are: the hydraulic press, the hand pump, and the pressure gauge with the attachment for the controlling weights. The machine is filled with oil and a pressure of 3000 kilograms (6614 lbs.) is produced by about ten strokes of the hand pump.

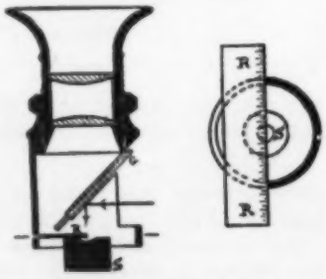

FIG. 2—MICROSCOPE

A special microscope shown in Fig. 2 is provided to read the width of impressions. The reflector G furnishes a strong illumination for the test piece S and with the aid of the small steel rule R fitted in the bottom of the cylinder, the exact diameter can be read to 1/10 of a millimeter.

Personal

Dr. **H. K. Benson** of the University of Washington, Seattle, Wash., is making a trip East and will attend the National Exhibition of Chemical Industries in New York City.

Mr. **William C. Coffin** has severed his connection with the Jones & Laughlin Steel Company, to become vice-president of the Knox Pressed & Welded Steel Company of Pittsburgh, Pa. Mr. Coffin was vice-president of the Riter-Conley Manufacturing Company from 1898 to 1908, and since then has been structural engineer of the Jones & Laughlin Steel Company. Mr. Coffin's new office will also include the duties of general sales manager. With the acquisition of Mr. Coffin the officers of the Knox Pressed & Welded Steel Company now are Luther L. Knox, president; William C. Coffin, vice-president and sales manager; Irvin F. Lehman, secretary and treasurer. The approaching completion of the new Knox plant was the deciding factor that brought Mr. Coffin to this company. The new plant of the Knox Pressed & Welded Steel Company will be given over to riveted and welded steel plate work, while the company's present plant at Farrell, Pa., will be continued in the manufacture of the Knox patented water-cooled devices for open-hearth and heating furnaces.

Dr. **C. H. Herty** of the University of North Carolina, president of the American Chemical Society, was recently in New York and did very effective good work for the National Exhibition of Chemical Industries, of whose advisory committee he is a member.

Mr. **Lewis A. Riley, 2d.**, mechanical and gas engineer, has taken over the agency in the United States and Canada for the Lymn system of by-product gas producers, which has made such rapid strides in Europe during the past five years. The Lymn system is an improvement and development of the Mond system of by-product gas production; it was described in some detail in our July issue, page 456. Mr. Riley has taken offices in the Vanderbilt Concourse Building, 52 Vanderbilt Avenue, New York City.

Book Review

The Mining Manual and Mining Year Book for 1915. By **Walter R. Skinner.** 968 pages. Price 15s. net (Post free in U. S. 17s.). London: Walter R. Skinner.

In this edition of this large annual devoted to data on the mining companies of the world, companies are arranged alphabetically instead of being divided into sections as heretofore. The reference data are very complete and contain besides the statements as to capital, data of registration, etc., an analysis of the last balance sheet, dividends from the start, details of ore reserves, borehole results and description and capacity of treatment plant. The volume contains particulars of 2420 companies and also an index of 2580 additional companies whose field of action has either ceased or is not of public interest. Alphabetical lists of mining directors, secretaries, engineers and mine managers are included as usual and a dictionary of mining terms is added. These features make a very complete work and it should prove of value to any one requiring up-to-date information on mining companies.